Kūshyār ibn Labbān's Glossary of Astronomy

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Kūshyār ibn Labbān is an Iranian astronomer and mathematician who wrote his major astronomical work al- $Z\bar{\imath}j$ al- $J\bar{a}mi^{\circ}$ (lit. "The comprehensive astronomical handbook with tables", abbreviated here as ZJ) between 1020 and 1025 C.E. [Kennedy 1956, pp. 125, 156-57; Bagheri 2006, p. 1]. This Arabic treatise consists of four Books: I) Elementary calculations, II) Tables, III) Cosmology, and IV) Proofs. I have prepared an edition of Books I and IV with English translation and commentary as my PhD dissertation at Utrecht University. I am now working on Books II and III of ZJ in order to complete the work for publication.

We know very little about Kūshyār's life [Bagheri 2006, pp. 1-2], however, there is an interesting quotation from him which was not noticed before. In MS Cairo, Dār al-kutub Mīqāt no. 691 (Books I and II of ZJ), fol. 24v, there is a note by the scribe at the end of Book I as follows:

Kūshyār said:

"<I> observed the conjunction of Mars and Saturn with <my own> eyes in nightfall of Thursday 21 of Tīrmāh of the year 362 of Yazdigird (=11 July 993 C.E.). Then I found their true longitudes for the <local> meridian. <According to the result,> Saturn was in Pisces 0;59° and Mars in it (i.e., in Pisces) 1;50°, at the beginning of its retrogradation, by subtracting two degrees from its mean longitude and adding two degrees to its mean anomaly. <I did this> in order the make it sure for myself that one may not rely on observational $z\bar{\imath}j$ es. Because if they turn out to be correct in one <case> by some tricks, they are erroneous in ten <case>. There is no way to correcting them by the scientists of our time and by efforts of our rulers. And greetings (i.e., that's all)."

This is his (i.e., Kūshyār's) saying quoted from a manuscript in his hand.¹

قال كوشيار قرآن المريخ و رحل برأى العين عشية يوم الخميس الحادى والعشرين من تيرماه سنة اثنين وستين اوثلثمائة ليردجرد فقومتها لنصف النهار فكان زحل في الحوت ، نط المريخ فيه آن في اول رجوعه بنقصان درجتين من وسطه و زيادة درجتين على خاصته ليتحقق عني ان الزيجات الرصدية لا اعتماد عليها لانها ان اصابت في واحد ببعض الحيل اخطأت في عشرة ولا سبيل على تصحيحها بعلماء زماننا وهم ملوكنا والسلم هذا قوله ومنقول من نسخة نخطه

There is a similar note in MS Cairo, Dār al-kutub Mīqāt no. 400 (Books I and II of ZJ), fols. 42r-42v.

In Chapter 31 of Book III, entitled Al- $b\bar{a}b$ al-mufrad $f\bar{\imath}$ $jaw\bar{a}mi$ ° 'ilm al-hay'a (lit. "A special chapter on generalities of the science of cosmology"), Kūshyār defines the astronomical terms which he uses in ZJ. In the list of the chapter titles given at the beginning of Book III, it is mentioned that the astronomical terms are ordered "according to <the subjects discussed in> the chapters of Book I".²

This interesting and useful chapter was sometimes copied and circulated as an independent treatise (mss. T, C and D below). In the preparation of this paper, I have used the following manuscripts (the symbol in the beginning is the abbreviation for the ms.; folio nos. at the end of each item is for Chapter 31):

- C Cairo, Dār al-kutub, MS Muṣṭafā Fāḍil Mīqāt 158/2 [King 1981-1986, I, p. 395; II, pp. 105-06]; Chapter 31 of Book III, copied in 1182 A.H./1768-69 C.E., fols. 21v-28r.
- D MS Daiber collection III, courtesy of Hans Daiber; Chapter 31 of Book III, copied in 863 A.H./1458-59 C.E., pp. 8-17.
- F Istanbul, Fatih, MS 3418/1 [Krause 1936, p. 472] (Handlist of mss., p. 196); Books I-IV, copied in 545 A.H./1150-51 C.E., fols. 1v-175v (119v-125v).
- L Leiden Universiteitsbibliotheek, MS Or. 8 [Voorhoeve 1957, p. 405; De Jong & De Goeje 1865-1866, III, 84-86, no. 1054]; Books I-IV, copied in 634 A.H./1236-37 C.E., fols. 1v-124r (97r-99v).
- M Moscow, Russian State Library, MS 154/3 [Matvievskaya & Rosenfeld 1983, II, p. 217]; Books III and IV, copied in 525 A.H./1130-31 C.E., fols. 36v-111r (64v-69v).
- T Cairo, Dār al-kutub, MS Ṭal'at Majāmī' 811/18 [King 1981-1986, I, p. 564; II, pp. 105-06]; Chapter 31 of Book III, copied in 1063 A.H./1652-53 C.E., fols. 198v-202r.
- Y Istanbul, Yeni Cami, MS 784/3 [Krause 1936, p. 472], (Handlist of mss., Ahmed III, p. 64); Books I-IV, copied in the 6th century A.H./12th century C.E., fols. 230r-362r (336r-339v).

There is another manuscript of this single chapter in MS Princeton, Mach 4898=Yahuda 373, fols. 320v-325r, copied around 1050 A.H./1640 C.E. and titled Risālat fī jawāmi' ta'rīfāt 'ilm al-hay'a ("Treatise on the generalities of the definitions of the science of cosmology") [Mach 1977, p. 422; King 1986, p. 45]. This manuscript was unavailable to me. There is also an (unnumbered) ms. of Chapter 31 written in Hebrew characters in the collection of Rabbi Qāfiḥ (Jerusalem) prepared by himself in Ṣan'ā during the 1920's [Langerman 1996, p. 151], which was

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 $^{^{2}}$ على ترتيب ابواب المقالة الأولى

inaccessible to me.

In this paper, I have used F, the oldest complete ms. of ZJ, as the basis for edition, and M as an alternative ms. These two and the ms. D provide similar versions of Kūshyār's glossary of astronomy. Other mss. deviate from these versions for the order of the terms and sometimes for the descriptions and they are not copies of the same version. Only ms. T is almost similar to Y (see also the "Commentary" below). All the mss. present the order number of the entries using abjad numerals, except ms. D in which Hindu-Arabic numerals are applied for this purpose.

In the English translation, I have tried to keep the structure of the original sentences. However, I have provided some additional words in angular brackets, i.e., < > in order to make the translation understandable. My explanatory notes in the text are given inside parentheses, i.e., (). The transliteration of each Arabic astronomical term is also given in parentheses. In the edition of the Arabic text I have used "om." and "add." in the footnotes to denote omitted and added words, respectively.

Translation

A Special Chapter on the Generalities of the Science of Cosmology

- 1. Era (al-tā'rīkh): A known day to which the time which has passed is referred.
- 2. Circle ($al-d\bar{a}'ira$): An area bounded by a single <curved> line inside which <exists> a point <such that> all straight line <segment>s drawn from this point to the circumference are equal. This point is <called> the center of the circle.
- **3.** Diameter (al-quir): The straight line <segment> that connects the two endpoints of a semicircle arc, so it inevitably passes through the center of the circle.
- **4.** Chord (*al-watar*): The straight line <segment> that connects the two endpoints of a partial arc of the circle.
- 5. Sine of the arc (jayb al-qaws): The straight line < segment> drawn from one endpoint of the arc standing at right angles on the diameter drawn from the other endpoint. It is also half the chord of the doubled arc.
- **6.** Versed Sine (al-jayb al-ma'k $\bar{u}s$): A portion of the diameter between the endpoint of the arc and its Sine. It is also the Sagitta of the doubled arc.
- 7. Gnomon (al- $miqy\bar{a}s$): A straight body either perpendicular to the horizon plane or parallel to the horizon plane. It may be either divided into 12 <parts> called "digits" or into 7 or 61/2 <parts> called "feet". It may <also> be divided into other <numbers of> parts. Its shadow is used in <certain> types of operations.
- **8.** Tangent (First Shadow) for any arc (al-zill al-awwal li-kull qaws): It is obtained from the gnomons parallel to the horizon plane. It is the line <segment> drawn from the foot of the gnomon parallel to the Sine of the arc.
- 9. Cotangent (Second Shadow) for any arc (al-zill al-thānī li-kull qaws): It is obtained from the gnomons perpendicular to the horizon plane. It is the line <segment> drawn from the foot of the gnomon parallel to the Cosine of the arc.
- 10. Arctangent (Arc of the Shadow) (qaws al-zill): The altitude arc for which the shadow of the gnomon is <cast>.
- 11. Secant (Hypotenuse of the Shadow) (qutr al-zill): The line <segment> that connects the tip of the gnomon and the end of the shadow.
- 12. Sphere of the whole (kurat al-kull): The moving sphere that makes all stars move from east to west, a single rotation during each nychthemeron (lit. "day

and night").

- 13. Great circles (al- $daw\bar{a}$ 'ir al-' $iz\bar{a}m$): <The circles> whose planes pass through the center of the sphere and cut <the sphere> into two halves.
- 14. Circle of the equator $(d\bar{a}'irat\ mu'addil\ al-nah\bar{a}r)$: <The circle> drawn <with its pole> at the pole of the sphere of the whole (i.e., the north or south pole) and its distance (i.e., the arc of great circle between its pole and its circumference) <equal> to a quadrant of the great circle.
- 15. Circle of the ecliptic $(d\bar{a}'irat\ falak\ al\text{-}bur\bar{u}j)$: <The circle> described by the sun through its proper motion from west to east, a single rotation in <each> year.
- 16. Circle of the horizon $(d\bar{a}'irat\ al\text{-}ufuq)$: Dividing <circle> between the visible <part> of the <celestial> sphere and <its> hidden <part> and its pole is the zenith.
- 17. Circle of the meridian $(d\bar{a}'irat\ al-nisf\ al-nah\bar{a}r)$: <The circle> whose poles are the equinoctial rising and setting points <of the sun>. It intersects the circle of the horizon at right angles.
- 18. Altitude circle $(d\bar{a}'irat\ al\text{-}irtif\bar{a}')$: <The circle> which passes through the zenith and the given star (or planet).
- 19. Orbs (aflāk): <They are> nine <orbs>; seven <orbs> for the moving stars (i.e., planets), the eighth <orb> for the fixed stars, and the ninth is the moving <orb> which makes all these <orbs> move.
- **20.** Sphere of each star (i.e., planet) (kurat kullu kawkab): <The sphere in> which all the motions <of the planet> are contained.
- 21. Parecliptic orb in any sphere (al-falak al-mumaththil $f\bar{\iota}$ kull kura): A circle in the plane of the ecliptic and <centered> at its center.
- 22. Inclined orb in any sphere (al-falak al- $m\bar{a}$ 'il $f\bar{\imath}$ kull kura): A circle whose center is <the same as> the center of the ecliptic orb and whose plane is inclined with respect to its (i.e., the ecliptic orb's) plane.
- 23. Eccentric orbs (al-aflāk al-khārijat al-marākiz): The circles in the planes of the inclined orbs. Their centers are apart from the center of the inclined orb. <For the case of> the sun, <the eccentric orb> is <situated> in the plane of the parecliptic orb.

24. Epicycles ($afl\bar{a}k$ al- $tad\bar{a}w\bar{i}r$): Small circles whose centers <are> on the circumferences of the eccentric orbs.

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- 25. Mean longitude of the sun (wasaṭ al-shams): An arc of the parecliptic orb between the beginning of Aries and the line drawn from the center of the eccentric orb passing through the body of the sun.
- **26. Apogee** (*al-awj*): Farthest position on the circumference of the eccentric orb from the center of the ecliptic orb.
- 27. Mean anomaly of the sun $(kh\bar{a}ssat\ al-shams)$: An arc of the parecliptic orb between the apogee and the line drawn from the center of the eccentric orb to the sun.
- **28. Equation of the sun** (ta $^{\circ}d\bar{\imath}l$ al-shams): An angle <whose vertex is> at the body of the sun on the circumference of the eccentric orb constructed by the two lines drawn from the center of the parecliptic orb and the center of the eccentric orb.
- **29.** True longitude of the sun (taqwīm al-shams): An arc of the parecliptic orb between the beginning of Aries and the line drawn from the center of the ecliptic orb to the sun.
- **30. Mean day** (*al-yawm al-wasaṭ*): <The duration of> one rotation of the equator from a noon to <the next> noon plus an extra arc equal to the daily mean motion of the sun.
- **31.** True day (al-yawm al- $haq\bar{q}q\bar{q}$): <The duration of> one rotation of the equator, as we have said, plus an extra <arc equal to the> increase of the sun's true longitude by the <next> noon.
- **32. Equation of time** $(ta'd\bar{\imath}l\ al-ayy\bar{a}m\ bi-lay\bar{a}l\bar{\imath}h\bar{a})$: <The summation of> the difference between the mean day and the true day.
- 33. <Geographical> longitude of <any> locality ($t\bar{u}l$ al-balad): An arc of the equator between the meridian circle passing through the end of the inhabited <lands> and the meridian circle of the locality. <The arc> of the equator between the meridians of two localities is <called> "<the distance> between the two <geographical> longitudes" ($m\bar{a}$ bayn $al-t\bar{u}layn$).
- **34.** Mean longitude of the moon (wasaṭ al-qamar): An arc of the parecliptic orb between the beginning of Aries and the plane that passes through the center of this (i.e., the parecliptic) orb and the center of the epicycle (this plane is perpendicular to the parecliptic plane). <The magnitude of> this arc is the same < whether

it is taken> from the parecliptic orb or from the inclined <orb>.

- **35.** Mean anomaly of the moon $(kh\bar{a}ssat\ al-qamar)$: Its distance from the apogee of the epicycle <counted> in the opposite order <of the zodiacal signs>.
- **36.** Double elongation \langle of the moon \rangle (al-bu'd al-muḍā'af): An arc of the parecliptic orb between the position of its apogee and the plane that passes through the center of this (i.e., parecliptic) orb and the center of the epicycle (perpendicular to the parecliptic plane).
- 37. First equation <of the moon> (al-ta'dīl al-awwal): An angle <with its vertex> at the center of the epicycle, constructed by the two lines drawn from the center of the parecliptic orb and the prosneusis> point on the rectilinear extension of <the line segment that joins> the apogee and perigee of the epicycle. This point has been mentioned in Chapter 30 (in fact, in Chapter 17 of Book III; see the relevant footnote in the Arabic edition).
- 38. True anomaly and adjusted mean anomaly < of the moon > (al- $tadw\bar{\imath}r$ wa'l- $kh\bar{a}ssat$ al-mu'addala): An arc of the epicycle between the moon and the plane drawn from the center of the parecliptic orb that passes through the center of the epicycle (this plane is perpendicular to the parecliptic plane).
- **39. Second equation** <**of the moon**> (al-ta' $d\bar{\imath}l$ al- $th\bar{a}n\bar{\imath}$): An angle <with its vertex> at the center of the parecliptic orb, constructed by the two lines drawn from this center to the center of the epicycle and to the body of the moon.
- **40.** Difference ($ikhtil\bar{a}f$): The difference between <the magnitudes of> the radius of the epicycle as seen at its maximum distance <from the earth> and as seen at its minimum distance.
- 41. Sixtieths ($daq\bar{a}$ 'iq al-nasab): A number whose ratio to 60 minutes is equal to the ratio of the actual "difference" (see above) relating to the center of the epicycle to the maximum "difference" in this position.
- 42. True longitude of the moon ($taqw\bar{t}m$ al-qamar): An arc of the parecliptic orb between the beginning of Aries and the plane that passes through the center of this (i.e., the parecliptic) orb and the body of the moon (this plane is perpendicular to the parecliptic plane).
- **43.** Node (*jawzahar*): It <refers to> the two nodes created by the intersection of the inclined orb and the parecliptic <orb> for any star (i.e., planet; or the moon).
- 44. Mean longitude of a star (i.e., planet) (wasaṭ al-kawkab): An arc of the parecliptic orb between two planes passing through the center of the equant orb,

one which passes through the beginning of Aries and the other through the center of the epicycle (these two planes are perpendicular to the parecliptic orb).

- 45. Mean anomaly of a star (i.e., planet) $(kh\bar{a}ssat\ al-kawkab)$: Its distance from the apogee of the epicycle <counted> in the order <of the zodiacal signs>.
- **46. Mean centrum** (*markaz*): An arc of the parecliptic orb between the two planes passing through the center the equant orb, one of which ends at the apogee and the other at the center of the epicycle.
- 47. First equation <of a star (i.e., planet)> (al-ta'dīl al-awwal): An angle <with its vertex> at the center of the epicycle constructed by the two lines drawn from the center of the parecliptic orb and the center of the equant orb.
- 48. True anomaly and adjusted mean anomaly <of a star (i.e., planet)> (al-tadwīr wa'l-khāṣṣat al-mu'addala): An arc of the epicycle between the two planes passing through the center of the epicycle, one of which passes through the apogee of the epicycle and the other through the star (i.e., planet).
- 49. Adjusted centrum (al-markaz al-mu'addal): An arc of the parecliptic orb between the two planes passing through the center of the parecliptic orb, one of which passes through the apogee and the other through the center of the epicycle (these two planes are perpendicular to the parecliptic plane).
- **50.** Second equation < of a star (i.e., planet)> (al-ta $^{\circ}d\bar{\imath}l$ al- $th\bar{a}n\bar{\imath}$): An angle < with its vertex> at the center of the parecliptic orb constucted by the two lines drawn from it (i.e., the center) to the center of the epicycle and to the body of the star (i.e., planet).
- **51.** Difference ($ikhtil\bar{a}f$): The difference between <the magnitudes of> the radius of the epicycle as seen at its mean distance <from the earth> and as seen at its maximum and minimum distance.
- **52.** The true longitude of a star (i.e., planet) (taqwīm al-kawkab): An arc of the parecliptic orb between the two planes passing through its center, one of which passes through the beginning of Aries and the other through the body of the star (i.e., planet).
- **53.** Argument of latitude (*ḥiṣṣat al-'arḍ*): The distance of the moon or the star (i.e., planet) from the northern (i.e., ascending) node which is <also> called "head" (*al-ra's*).
- **54.** Latitude (al-'ard): An arc of the great circle that passes through the two poles of the ecliptic, between the star (i.e., planet; or the moon) and the ecliptic.

- **55.** Arc of retrogradation ($qaws\ al\text{-}ruj\bar{u}^{\varsigma}$): An arc of the epicycle between the two stations closer to the perigee.
- 56. Apparition and occultation of a star (i.e., planet) ($zuh\bar{u}r$ al-kawkab wa khafā'uhu): It is <regarded> under the sun's light rays, either in the early mornings or in late evenings.
- 57. Ascension of a star (i.e., planet) ($su^{c}\bar{u}d$ al-kawkab): Either <the star (i.e., planet)'s motion> towards the apogee or towards the perigee of the epicycle, and its descension ($hub\bar{u}t$) is <its motion> away from one of these two positions.
- 58. Partial first declination (al-mayl al-awwal al-juz'ī): An arc segment of the circle that passes through the two poles of the equator, between the ecliptic and the equator.
- **59.** Partial second declination (al-mayl al- $th\bar{a}n\bar{\imath}$ al-juz' $\bar{\imath}$): An arc segment of the circle that passes through the two poles of the ecliptic, between the equator and the ecliptic.
- 60. Total declination in the two <above> declinations (al-mayl al-kull $\bar{\imath}$ $f\bar{\imath}$ 'l-maylayn): An arc segment of the circle that passes through the poles of the two circles (ecliptic and equator), between the ecliptic and the equator.
- 61. Positions (i.e., localities) on the $\langle \text{terrestrial} \rangle$ equator line $(maw\bar{a}di^c khatt\ al\text{-}istiw\bar{a}')$: The circle on the earth's surface in the plane of the equator.
- 62. Right ascension (Ascensions <at> the equator line) (matali khattali al-istawa): <The arc> of the equator that rises <simultaneously> with an arc of the ecliptic <as observed> in the positions (i.e., localities) on the <terrestrial> equator line. It is <also> an arc of the equator circle contained by two <great> circles drawn from the pole of the equator that pass through the two extremes of the arc of the ecliptic.
- **63.** Inverse of the <right> ascension ('aks al-maṭāli'): An arc of the equator between the two <great> circles that pass through the pole of the ecliptic and through the two extremes of an arc of it (i.e., of the ecliptic). It is the inverse of the <right> ascension of the arc of the ecliptic between these two <great> circles.
- **64.** Distance of a star from the equator (bu'd al-kawkab 'an mu'addil al- $nah\bar{a}r$): An arc of the $\langle \text{great} \rangle$ circle that passes through the two poles of the equator, between the star and the circle of the equator.
- 65. <Geographical> latitude of the locality ('ard al-balad): An arc of the meridian circle between the zenith and the circle of the equator, or between the pole

of the equator and the horizon (the two arcs are equal).

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- **66.** Ortive amplitude (*si* 'at al-mashriq): An arc of the horizon circle between the equinoctial rising point <of the sun> and the rising point of the sun on that <given> day.
- 67. Equation of daylight of the $\langle \text{given} \rangle$ part (i.e., degree) of the ecliptic (ta' $d\bar{\imath}l$ $nah\bar{a}r$ al-juz' min falak al- $bur\bar{\imath}u$): The difference between the right ascension of the $\langle \text{ecliptical} \rangle$ degree and its oblique ascension (see no. 69). It is an arc of the equator between two circles that pass through the $\langle \text{given ecliptical} \rangle$ degree, one of which $\langle \text{is drawn} \rangle$ from the pole of $\langle \text{the circle of} \rangle$ the beginning of the azimuths (i.e., the great circle through the zenith in the east west direction; its pole is the north point on the horizon) and the other from the pole of the equator.
- **68.** Equation of daylight of a star $(ta^{\circ}d\bar{\imath}l \ nah\bar{a}r \ al\text{-}kawkab)$: An arc of the equator between the two circles that pass through the star, one of which <is drawn> from the pole of <the circle of> the beginning of the azimuths and the other from the pole of the equator.
- **69. Oblique ascension** ($ma
 otin ali^c$ al-balad): <The arc> of the equator that rises <simultaneously> with an arc of the ecliptic <as observed> in this horizon (i.e., in the given locality). It is <also> an arc of the equator between the two <great> circles drawn from the pole of <the circle of> the beginning of the azimuths (i.e., the north point on the horizon) that pass through the two extremes of the arc of the ecliptic.
- 70. Maximum altitude of the sun or a star $(gh\bar{a}yat\ irtif\bar{a}^c\ al\text{-}shams\ aw\ al\text{-}kawkab})$: An arc of the meridian circle between the horizon and the sun or the star.
- 71. Parallel circles $(daw\bar{a}'ir\ al\text{-}mad\bar{a}r\bar{a}t)$: <The small circles> parallel to the equator drawn <with their poles> at its (i.e., the equator's) pole and at different distances.
- 72. Half the day arc of the sun or a star (niṣf qaws al-nahār al-shams aw al-kawkab): An arc of a parallel circle between the horizon and the meridian. Its magnitude is the arc "similar" to it on the equator. This "similar" <arc> is the arc <of the equator> situated between the two arcs <of the great circles> drawn from the pole of the sphere (i.e., the pole of the equator) <through the endpoints of the arc on the parallel circle>.
- 73. Equinoctial hours <contained in one day $> (al-s\bar{a} \dot{a}t \ al-must aw\bar{\imath}ya)$: It is <obtained> by dividing the day arc by 15 <degrees>.

- 75. < Ecliptical > degree of transit of a star (darajat mamarr al-kawkab): The intersection point of the ecliptic circle and the circle that passes through the two poles of the equator and the star.
- 76. <Ecliptical> degree of the rising of a star ($darajat
 otinula u^c al-kawkab$): The point of the ecliptic orb <such> that the semi-circle of the eastern horizon passes both through it and the star <simultaneously>.
- 77. $\langle \text{Ecliptical} \rangle$ degree of the setting $\langle \text{of a star} \rangle$ (darajat al-ghurūb): The point of the ecliptic orb $\langle \text{such} \rangle$ that the semi-circle of the western horizon passes through it and the star $\langle \text{simultaneously} \rangle$.
- 78. Altitude of \langle a star at a given \rangle time ($irtif\bar{a}^{\circ}$ al-waqt): An arc of the altitude circle between the horizon and the star.
- 79. Arc of revolution (Revolved <portion> of the orb) (al-dā'ir min al-falak): An arc of the parallel circle between the horizon and the sun or the star at <the time of> measurement; it is a segment of the day arc.
- 80. Sagitta of the day arc $(sahm\ qaws\ al-nah\bar{a}r)$: The segment common to the semi-circle of the meridian and the segment of the parallel circle above the earth (i.e., above the horizon).
- 81. Arrangement Sines of the arc of revolution ($juy\bar{u}b$ $tart\bar{t}b$ $al-d\bar{a}$ 'ir): The segments common to the segment of the parallel circle above the earth (i.e., above the horizon) and the semi-circles parallel to the meridian circle.
- **82.** Ascendant ($al-t\bar{a}li$): The point of the ecliptic which is on the eastern horizon at \langle the time of \rangle measurement.
- 83. Equalization of houses ($taswiyat\ al\text{-}buy\bar{u}t$): The division of the ecliptic orb into 12 parts <so that> each part passes the meridian circle in two seasonal hours.
- **84.** Rate of a star (i.e., planet) (buht al-kawkab): Its true motion in a day or an hour.
- **85.** Lunar gain (sabq al-qamar): The excess of its (i.e., the moon's) rate over the sun's rate.
- **86.** Diameter of the two luminaries (qutr al-nayyirayn): The diameter of the apparent circle of their surface. It is also called "the magnitude (i.e., the thickness

or width) of the orb".

- **87.** Diameter of the shadow (quir al-zill): The diameter of the largest circle that occurs in the cone of the earth's shadow where the moon passes. It is <also> called "the orb of the node".
- **88.** Conjunction $(al\text{-}ijtim\bar{a}^c)$: <The situation in which> the center of the earth, the center of the moon, and the center of the sun are in the plane of a single circle, while this circle passes through the two poles of the ecliptic orb.
- **89.** Solar eclipse conjunction (al- $ijtim\bar{a}^c$ al- $kus\bar{u}f\bar{i}$): <The situation in which> the body of the moon and the body of the sun are on the <single> line that passes from <our> sight to them.
- **90.** Opposition (al-istiq $b\bar{a}l$): <The situation> in which the center of the sun, the center of the earth and the center of the moon are in the plane of a single circle that passes through the two poles of the ecliptic orb.
- **91.** Lunar eclipse opposition (al-istiq $b\bar{a}l$ al-khus $\bar{u}f\bar{i}$): <The situation> that these three centers (mentioned above) or the <three> bodies on a single straight line.
- **92.** Lunar eclipse ($khus\bar{u}f$ al-qamar): The falling of it (i.e., of the moon) in the cone of the earth's shadow.
- 93. <Magnitude of a> lunar eclipse in minutes ($daq\bar{a}'iq\ al\text{-}khus\bar{u}f$): <The portion> of the diameter of the circle of the moon's <apparent> surface which is covered
 the earth's shadow>.
- 94. <Magnitude of a> lunar eclipse in digits $(as\bar{a}bi^c al-khus\bar{u}f)$: The <portion> of its (i.e., moon's) diameter which is covered, in which <we take> the diameter <equal to> 12 digits.
- **95.** Adjusted <magnitudes in> digits (al-aṣābiʿ al-muʿaddala): <The portion> of its (i.e., the moon's or sun's) <apparent> surface which is covered (by the earth's shadow or the moon), in which <we take> the area of its surface <equal to> 12 digits.
- **96.** Times of a lunar eclipse ($azm\bar{a}n$ al- $khus\bar{u}f$): <They are> five <times;> the beginning of the lunar eclipse; the beginning of the duration <of totality>; the completeness of the lunar eclipse, which is the true <time of> opposition and is called the middle of the lunar eclipse; the beginning of the emersion <of the eclipse>; and the completeness of the emersion.

- **97. <Magnitude of> immersion in minutes** ($daq\bar{a}'iq\ al\text{-}suq\bar{u}t$): An arc of the inclined orb between the beginning of the lunar eclipse and its completeness, and between the completeness of the lunar eclipse and the completeness of the emersion <of the eclipse>.
- **98.** Adjusted times <of a lunar eclipse> (al-azmān al-mu'addala): These (above mentioned) times adjusted by taking account of the moon's latitude in each time.
- **99.** Distance of the two luminaries from the earth (bu'd al-nayyirayn min al-ard): <The length of> the line <segment> connecting the center or the surface of the earth to the moon or the sun.
- 100. Parallax (*ikhtilāf al-manṣar*): An arc of the altitude circle between the position of a star (i.e., planet) <if it is> measured from the center of the earth and its (i.e., the planet's) position <if it is> measured from the surface of the earth.
- 101. The six angles which are needed in <the calculations of> the solar eclipses (al-zawāyā al-sitt allatī taḥtāj ilayhā fī'l-kusūfāt al-shamsīya): The angles created by the intersection of the ecliptic orb and the altitude circle at the <ecliptical> degree of the moon. In each intersection, the desired <angle> is one of the two northern angles which is less than a right <angle>, and it is <called> "the latitude angle". Its complement to 90 <degrees> is <called> 'the longitude angle'.
- 102. Longitudinal parallax ($ikhtil\bar{a}f$ al-manz ar $f\bar{\imath}$ il- $t\bar{\imath}ul$): <The distance> between the position of the true longitude of the moon on the ecliptic orb and <the true longitude of> its apparent position on it (i.e., on the ecliptic).
- 103. Latitudinal parallax (*ikhtilāf al-manṣar fī'l-'arḍ*): <The difference> between the true latitude of the moon and its apparent latitude <measured> along a circle that passes through the poles of the ecliptic orb.
- **104.** Apparent latitude (al-'ard al-mar'i): An arc of the circle that passes through the two poles of the ecliptic orb between the apparent position of the moon on the altitude circle, and the circle of the ecliptic orb.
 - 105. Eclipse of the sun ($kus\bar{u}f$ al-shams): Its coverage by the moon.
- 106. The times of a solar eclipse ($azm\bar{a}n$ $al-kus\bar{u}f$): <They are> three <times:> the beginning of the solar eclipse; the completeness of the solar eclipse, which is its middle and the true <time of> conjunction; and the completeness of the emersion.

- 107. Adjusted times <of a solar eclipse> (al-azmān al-mu'addala): These are (above mentioned) three times, adjusted by taking account of the latitude of the moon.
- 108. Arc of vision (qaws al-ru'ya): An arc of the altitude circle between the horizon while the star (i.e., planet) is on it and the sun below the earth (i.e., below the horizon). This arc may also be taken on the altitude circle between the star (i.e., planet) while it is above the earth (i.e., above the horizon) and the horizon while the sun is on it.
- 109. Distance of the $\langle \text{ecliptical} \rangle$ degree of a star (i.e., planet) from the cardines (bu'd darajat al-kawkab min al- $awt\bar{a}d$): $\langle \text{The distance in terms of} \rangle$ seasonal hours between the degree of the star (i.e., planet) and the cardine (i.e., the meridian or the horizon) from which the distance is taken, $\langle \text{in terms of} \rangle$ seasonal hours.
- 110. Projection (Casting) of the ray by means of equal (i.e., ecliptical) degrees (ma!ra!, al-shu' \bar{a} ' bi-daraj al- $saw\bar{a}$ '): Arcs in the order <of the zodiacal signs> whose magnitudes are 60, 90, 120 and 180 degrees, taken on the ecliptic orb, if the star (i.e., planet) has no (i.e., zero) latitude; if it has a <non-zero> latitude, <the arcs are taken> from the circle that passes through the body of the star (i.e., planet).
- 111. Projection of the ray by means of ascensional (i.e., equatorial) degrees ($ma\rlap/ra\rlap/n$ al-shu' \bar{a} ' bi-daraj al- $ma\rlap/rali$ '): It is <similar to> the equalization of the houses, based on substituting the <ecliptical> degree of the star (i.e., planet) here for the ascendant there, and the equalization is <carried out> according to the <oblique> ascension for the horizon of the star's (i.e., planet's) position (see the next entry).
- 112. Horizon of a star's (i.e., planet's) position (ufuq mawḍiʿ al-kawkab): The circle that passes through the star (i.e., planet) and the intersection <point> of the meridian circle and the horizon circle.
- 113. Prorogation (al- $tasy\bar{v}r$): The <time span of the> arrival of an <ecliptical> degree which rises later, at the position of <another ecliptical> degree which rises earlier, through the general rotation <of the sphere>, taking each degree between them in terms of the <oblique> ascension for <the horizon of> the early-rising <ecliptical> degree's position <equal to> a year, a month or a day.
- 114. Transfer of the year (taḥwīl al-sana): The return of the sun to its initial position. This <takes place> in each 365 days, 5 hours, 46 minutes and 24 seconds of an hour.

- 115. Altitude with no (i.e., zero) azimuth (al- $irtif\bar{a}$ $^{\circ}$ $alladh\bar{\imath}$ $l\bar{a}$ samt lahu): An arc of the altitude circle passing through the sun or the star (i.e., planet) and through the equinoctial rising point < of the sun>.
- 116. Azimuth of an altitude ($samt\ al$ - $irtif\bar{a}$ °): An arc of the horizon circle between the equinoctial rising point < of the sun> and the place where the altitude circle meets the horizon.
- 117. Azimuth <measured> from the ascendant (al-samt min al- $t\bar{a}li'$): An arc of the horizon circle between the ecliptic orb and the altitude circle.
- 118. Argument of the azimuth (hissat al-samt): The line < segment > drawn from the foot of the perpendicular line through the body of the sun < on the horizon >, perpendicular towards the intersection of the parallel circle and the horizon < plane >.
- 119. Equation of the azimuth (ta' $d\bar{t}l$ al-samt): It is <similar to> this (i.e., the above mentioned) line <segment> perpendicular to the intersection of the equator and horizon <planes> (i.e., between the foot of the vertical line and the intersection between the two planes).
- 120. Argument of the altitude (his, at al-irtif \bar{a}): An arc of the altitude circle between its intersection with the equator and the horizon.
- 121. Equation of altitude $(ta^{c}d\bar{u} \ al-irtif\bar{a}^{c})$: An arc of the altitude circle between its intersection with the equator and the circle that passes through the two poles of the equator and the body of the sun.
- 122. Argument of the arc of revolution (his, at al-dā'ir): An arc of the equator between the horizon and the altitude circle.
- 123. Equation of the arc of revolution $(ta^c d\bar{u} \ al d\bar{a}'ir)$: An arc of the equator between the altitude circle and the circle that passes through the two poles of the equator and the body of the sun.
- 124. Meridian line (khatt nist al- $nah\bar{a}r$): The intersection of the plane of the meridian circle and the plane of the horizon circle.
- 125. Deviation of <the directions of> localities and (i.e., also called) their (i.e., the localities') 'azimuths' ($inhir\bar{a}f$ al-buld $\bar{a}n$ wa-samtuh \bar{a}): An arc of the horizon circle between the meridian circle and the altitude circle that passes through our zenith and their (i.e., those localities') zenith.
- 126. <Difference> between the <geographical> latitudes of two localities $(m\bar{a} \ bayn \ `ard \ al-baladayn)$: An arc of the meridian circle between our zenith

and the circle drawn around the pole of the equator and at a distance <from the equator equal to> the chord of the <geographical> latitude of those <localities>. It was already mentioned that <the difference> between two <geographical> longitudes is an arc of the equator between the two meridian circles of the two cities.

- 127. Distance between the two localities (al-bu'd bayn al-baladayn): An arc of the altitude circle between our zenith and their (i.e., those other localities') zenith.
- 128. Equation of $\langle \mathbf{geographical} \rangle$ longitude $(ta^{\circ}d\bar{\imath}l \ al-\underline{!}\bar{\imath}l)$: An arc of the circle that passes through the equinoctial rising point $\langle \mathbf{of} \ the \ sun \rangle$ for us (i.e., the east point on the horizon) and the zenith of those $\langle \mathbf{localities} \rangle$.
- 129. Equation of $\langle \text{geographical} \rangle$ latitude $(ta \dot{} d\bar{\imath} l \ al \dot{} ar\dot{q})$: An arc of the meridian circle between the circle of the equation of $\langle \text{geographical} \rangle$ longitude and the equator.
- 130. Adjusted latitude of a locality ('arḍ al-balad al-mu'addal): An arc of the meridian circle between our zenith and the circle of the equation of <geographical> longitude.
- 131. The fixed stars (al-kawākib al-thābita): They are different from the seven moving <star (i.e., planet)s>. They are not fixed, but their precessional> motion is very slow as compared to <the motion of> the star (i.e., planet)<s>. Also, since each of these stars is attached to one of the circles parallel to the belt of the sphere of the <zodiacal> signs (i.e., the ecliptic) and does not leave it, and its latitude does not change, they are called 'fixed'. This is what we wanted to mention in this chapter.

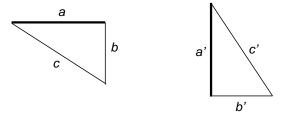
Commentary

In the text of ZJ, Kūshyār uses the term $ta'r\bar{\imath}kh$ (no. 1) for "era", "epoch" and "calendar" in different contexts (e.g., in Chapters 1 and 2 of the first section of Book I).

In no. 6, Kūshyār defines the terms such that $al\text{-}jayb\ al\text{-}ma\ k\bar{u}s$ ("Versed Sine") of an arc α is equivalent to $(60-60\cos\alpha)$ and its sahm ("Sagitta") to $(60-60\cos(\alpha/2))$ in modern notation (the radius of the circle is taken equal to 60 parts). This is consistent with the terminology used by al-Bīrūnī [1934, 4] and Ḥabash al-Ḥāsib [MS Berlin 57 Ahlwardt 5750 (WE. 90), fol. 80v]. However, in Chapter 4 of the second section of Book I of ZJ, Kūshyār's calculation method for the Sagitta of an arc leads to a result equivalent to $(60-60\cos\alpha)$ and he uses the term in the latter meaning in the body of his $z\bar{i}j$ (e.g., in Chapters 14 and 21 of the fifth section of

Book I and Chapter 13 of the fifth section of Book IV). Only in the manuscripts C and T the term al-jayb al-ma' $k\bar{u}s$ ("Versed Sine") is mentioned as an equivalent to sahm ("Sagitta") and the entry is presented under the term sahm. These may refer to a later correction by Kūshyār or someone else in order to achieve consistency.

Tangent and Cotangent (nos. 8 and 9) are equivalent to 60 times modern tangent and cotangent trigonometric functions. In the following drawing, a and a' are gnomons; b and b' are the First and the Second Shadows (Tangent and Cotangent), respectively; and c and c' are the Hypotenuse of the First and the Second Shadows (Secant or Cosecant).

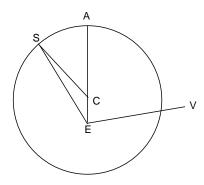


Qutr al-zill (no. 11) of an arc α is equivalent to $60 \sec \alpha$ or $60 \csc \alpha$ in modern notation depending on using a horizontal or vertical gnomon. Kūshyār mentions the same term in no. 87, but in the literal meaning "diameter of the shadow [of the earth]".

In no. 15 Kūshyār uses an expression for the ecliptic which literally means "circle of the orb/sphere of the <zodiacal> signs". However, the expression "sphere of the <zodiacal> signs" (falak al- $bur\bar{u}j$) may also refer to the "sphere of the fixed stars". Al-Kāshī used falak al- $bur\bar{u}j$ in the latter meaning in a Persian letter to his father [Bagheri 1997, pp 244, 252].

The earth is assumed to be at the center of the ecliptic, the parecliptic orb and the inclined orb (nos. 15, 21 and 22).

In the following figure, V is the direction of the vernal equinox, $\angle VEA + \angle ACS$ is the mean longitude of the sun (no. 25), A is its apogee (no. 26), $\angle ACS$ its mean anomaly (no. 27), $\angle ESC$ its equation (no. 28) and $\angle VES$ the true longitude of the sun (no. 29).



Kūshyār's astronomy is essentially based on Ptolemaic models. For more details

about the Ptolemaic lunar and star (i.e., planet)ary models which were used by Kūshyār see relevant chapters in [Ptolemy 1984; Pedersen 1974]. One may also consult my PhD thesis entitled Books I and IV of Kūshyār ibn Labbān's Jāmi Zīj: An Arabic astronomical handbook by an eleventh-century Iranian scholar which is planned to be put in the website of Utrecht University.

According to what we find in all mss. in no. 48, Kūshyār describes the 'true anomaly' (al-tadwīr) which is also called the 'adjusted mean anomaly' (al-khāṣṣat al-mu'addala) as an arc of the epicycle between two planes that pass through the center of the parecliptic orb, while the planes should pass through the center of the epicycle itself. The error has been corrected in the edition of the Arabic text. He apparently assumes that the two planes are perpendicular to the plane of the epicycle. However, he could simply define the 'true anomaly' as an arc of the epicycle between two radii of the epicycle.

The terms $zuh\bar{u}r$ ("apparition") and $khaf\bar{a}$ ' ("occultation") in no. 56 actually refer to the first and last visibility of a star (i.e., planet) after and before conjunction.

The term 'aks al-maṭāli' ("inverse of the <right> ascension") in no. 63 is only used in Chapter 3 of the fifth section of Book I for the calculation of the second declination.

In definitions no. 67 and no. 68, the description of the equation of daylight as arcs from the equator are correct only if we assume the ecliptical degree or the star to be on the horizon.

Eight entries are missing in Y (nos. 107, 117-123). Ms. T is copied from a version similar to Y, but the entries no. 73, 107 and 131 are missing in T.

Ten entries are missing in the ms. C (nos. 28, 45, 96, 118-123 and 131). However, C defines 10 extra entries missing in other mss. as follows: $al-had\bar{\iota}d$ ("perigee"), $al-falak\ al-mu^{\dot{\iota}}addil\ li^{\dot{\iota}}l-mas\bar{\iota}r$ ("equant orb"), $al-\dot{\iota}ard\ al-awwal$ ("first latitude"), $al-\dot{\iota}ard\ al-th\bar{\iota}al$ ("second latitude"), $al-\dot{\iota}ard\ al-th\bar{\iota}al$ ("third shadow"), $irtif\bar{\iota}a$ $quth\ falak\ al-bur\bar{\iota}uj$ ("altitude of the ecliptic orb") also called ' $ard\ iql\bar{\iota}m\ al-ru$ 'ya ("latitude of the clime of visibility"), $irtif\bar{\iota}a$ $al-qamar\ bi-hasab$ 'ardihi ("altitude of the moon taking account of its latitude"), $s\bar{\iota}a$ $al-taqw\bar{\iota}m$ ("hours of the true longitude"), $s\bar{\iota}a$ $al-tahw\bar{\iota}a$ ("hours of transfer"), and $al-tahw\bar{\iota}a$ ("lunar mansions").

The manuscript in Hebrew characters has 137 entries [Langerman 1996, p. 151]. These extra entries (over 131 entries in this edition) should be some of the extra entries in the ms. C.

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Arabic Text

الباب المفرد في جوامع علم الهيئة

- آ التاريخ يوم معلوم ينسب اليه زمان يأتي عليه
- ب الدائرة سطح يحيط به خط و احد في داخله نقطة كل الخطوط المستقيمة الخارجة من تلك النقطة الى المحيط متساوية و تلك النقطة مركز الدائرة
- ج القطر هو الخط المستقيم الواصل بين طرفي قوس نصف الدائرة فبالاضطرار يمر بمركز الدائرة
 - الوتر هو الخط المستقيم الواصل بين طرفي قوس بعض الدائرة
- جيب القوس هو الخط المستقيم الخارج من احد طرفي القوس قائماً على القطر الخارج من الطرف الآخر على زوايا قائمة وهو ايضاً نصف وتر ضعف القوس
 - الجيب المعكوس قطعة من القطر ما بين طرف القوس وجيبه وهو ايضاً سهم ضعف القوس
- \overline{c} المقياس شخص مستو اما قائم على سطح الافق و اما مواز لسطح الافق فاما ان يقسم باثنى عشر ويسمى اصابعاً و اما ان يقسم بسبعة او بستة و نصف ويسمى اقداماً و اما ان يقسم باقسام آخر فيستعمل ظله في وجوه من الاعمال
- ح الظل الاول لكل قوس هو المأخوذ من المقابيس الموازية لسطح الافق وهو خط يخرج من اصل المقياس موازياً لجيب القوس
- \overline{d} الظل الثاني لكل قوس هو المأخوذ من المقاييس القائمة على سطح الافق وهو خط يخرج من اصل المقياس مو ازياً لجيب تمام القوس
 - \overline{z} قوس الظل هي 3 قوس الارتفاع الذي بحسبه يكون ظل المقياس
 - يا قطر الظل هو الخط الواصل بين رأس المقياس ونهاية الظل
- يب كرة الكل هي الكرة المتحركة المحركة لجميع الكواكب من المشرق الى المغرب في كل يوم وليلة دورة واحدة
 - يج الدوائر العظام هي التي تمر سطوحها بمركز الكرة وتقطعها بنصفين

² M add. يكون

السطح M

³ M om.

- يد دائرة معدل النهار هي المخطوطة على قطب كرة الكل وببعد وتر ربع دائرة عظيمة
- يه دائرة فلك البروج هي التي ترسمها الشمس بخاصة حركتها من المغرب الى المشرق في السنة دورة واحدة
 - يو دائرة الافق هي الفاصلة بين الظاهر من الكرة وبين الخفى وقطبها سمت الرأس
 - يز دائرة نصف النهار هي التي قطباها مطلع الاعتدال ومغيبه وتقطع دائرة الافق على زوايا قائمة
 - يح دائرة الارتفاع هي التي تمر بسمت الرأس وبالكوكب المفروض
- \overline{M} الافلاك تسعة سبعة للكواكب السيارة وثامنها 4 للكواكب الثابتة والتاسع المتحرك المحرك 5 لهذه كلها
 - ك كرة كل كوكب هي التي يتضمن جملة حركاته
 - $\overline{\Delta}$ الفلك الممثل في كل كرة هي دائرة في سطح دائرة البروج و 6 على مركزها
 - كب الفلك المائل في كل كرة هي دائرة مركزها مركز فلك البروج وسطحها مائل عن سطحها
- كَج الافلاك الخارجة المراكز دوائر في سطوح الافلاك المائلة ومراكزها خارجة عن مركز الفلك المائل وللشمس في سطح الفلك الممثل
 - كد افلاك التداوير دوائر صغار مراكزها على محيط الافلاك الخارجة المراكز
- كه وسط الشمس قوس من الفلك الممثل ما بين اول الحمل والخط الخارج من مركز الفلك الخارج المركز ماراً بجرم الشمس
 - $\overline{2}$ الاوج ابعد موضع على محيط الفلك الخارج المركز من مركز 8 فلك البروج
- كر خاصة الشمس قوس من الفلك الممثل ما بين الاوج والخط الخارج الى الشمس من مركز الفلك الخارج المركز
- $\overline{2}$ تعدیل الشمس زاویة عند جرم الشمس علی محیط الفلك الخارج المركز ترتسم من خطین یخرجان من مركز الفلك الممثل ومركز الفلك 9 الخارج المركز
- كَطَ تقويم الشمس قوس من الفلك الممثل ما بين اول الحمل والخط الخارج من مركز فلك البروج اليى الشمس

 5 M التاسعة المتحركة المحركة

و ثامنه M

⁶ F om.

⁷ M add. •

⁸ M om.

⁹ F add. superfluous الفلك

- \overline{U} اليوم الوسط 10 هو دور واحد لمعدل النهار من نصف النهار الى نصف النهار وزيادة قوس منه مثل وسط الشمس ليوم 11
- \overline{Y} اليوم الحقيقي هو دور واحد لمعدل النهار كما قلنا وزيادة ما يجوز نصف النهار مع مسير الشمس المقوم
 - لب تعديل الايام بلياليها هو الاختلاف بين اليوم الوسط واليوم الحقيقي
- \overline{L} طول البلد قوس من معدل النهار ما بين دائرة 12 نصف النهار المارة بآخر العمارة ودائرة نصف نهار البلد وما بين نصف نهار البلدين من معدل النهار 13 هو ما بين الطولين
- $\overline{\text{Lc}}$ وسط القمر قوس من الفلك الممثل ما بين اول الحمل وبين السطح المار بمركز هذا الفلك ومركز فلك التدوير وهذه القوس من الفلك الممثل و 15 المائل واحد 15
 - له خاصة القمر بعده من ذروة فلك التدوير الى خلاف التوالي
- $\overline{\text{Le}}$ البعد المضاعف 16 قوس من الفاك الممثل ما بين موضع الأوج منه وبين السطح المار بمركز هذا الفلك ومركز فلك التدوير
- $\overline{\text{Li}}$ التعديل الاول زاوية عند مركز فلك التدوير ترسم 17 من خطين يخرجان من مركز الفلك الممثل ومن النقطة التي على استقامتها الذروة والحضيض من فلك التدوير وقد تقدم ذكر هذه النقطة في الباب الثلثين 18
- لح التدوير والخاصة المعدلة قوس من فلك التدوير ما بين القمر والسطح الخارج من مركز ¹⁹ الفلك الممثل ماراً بمركز فلك التدوير

الوسطى M

¹¹ M om.

الدائرة M الدائرة

¹³ M om. من معدل النهار

الفلك M add

و احدة M و احدة

المضعّف M

تر تسم M تر

¹⁸ D and Y الابواب الثاثين , L الابواب الثاثين instead of الباب الثاثين found in F and M. However, the term ta'dīl al-awwal (the first equation) is actually explained in Chapter 17 of Book III.

¹⁹ F om.

- $\overline{\mathbf{Ld}}$ التعدیل الثانی زاویة عند مرکز الفلك الممثل ترسم 20 من خطین یخرجان من هذا المرکز الی مرکز فلك التدویر والی 21 جرم القمر
- م الاختلاف هو اختلاف نصف قطر فلك التدوير بين ما يرى عند بعده الابعد وما يرى عند بعده الاقرب
- ما دقائق النسب عددٌ نسبته الى ستين دقيقة كنسبة الاختلاف اللازم حيث مركز فلك التدوير الى كل الاختلاف في ذلك الموضع
- مب تقويم القمر قوس من الفلك الممثل ما بين اول الحمل والسطح المار 22 بمركز هذا الفلك وبجرم القمر
 - مج الجوزهر هو العقدتان الحادثتان عن تقاطع الفلك المائل و 23 الممثل في كل كوكب
- مد وسط الكوكب قوس من الفلك الممثل بين سطحين يمران بمركز الفلك المعدل للمسير يمر الحدهما²⁴ باول الحمل و الآخر بمركز فلك التدوير
 - مه خاصة الكوكب بعده من ذروة فلك التدوير الى التوالى
- مو المركز قوس من الفلك الممثل بين سطحين يمران بمركز الفلك المعدل ينتهي احدهما²⁵ الى الاوج والآخر الى مركز فلك التدوير
- مز التعديل الاول زاوية عند مركز فلك التدوير ترتسم من خطين يخرجان من مركز الفلك الممثل ومركز الفلك المعدل للمسير
- مح التدوير والخاصة المعدلة قوس من فلك التدوير بين سطحين يمران بمركز الفلك التدوير ²⁶ فيمر احدهما بذروة فلك التدوير والآخر بالكوكب
- مط المركز المعدل قوس من الفلك الممثل بين سطحين يمران بمركز الفلك الممثل فيمر احدهما بالاوج والأخر بمركز فلك التدوير
- ت التعديل الثاني زاوية عند مركز الفلك الممثل ترتسم من خطين يخرجان منه الى مركز فلك التدوير والى جرم الكوكب

²¹ M om. الح

تر تسم M تر

المار instead of الذي يمر M

²³ M add. الفاك

احداهما M

احداهما M

²⁶ In all mss. الممثل instead of الندوير which is the correct word in the context

- نا الاختلاف هو اختلاف نصف قطر فلك التدوير بين ما يرى عند البعد الاوسط وما يرى عند البعد الابعد والاقرب
- نب تقويم الكوكب قوس من الفلك الممثل بين سطحين يمران بمركزه فيمر احدهما باول الحمل والآخر بجرم الكوكب
 - نج حصة العرض هي بعد القمر والكوكب من العقدة الشمالية التي يسمى الرأس
 - \overline{i} العرض 27 قوس من دائرة عظيمة تمر بقطبي فلك البروج ما بين الكوكب وفلك البروج
 - نه قوس الرجوع قوس من فلك التدوير ما بين وقفتى الكوكب مما يلى الحضيض
 - نو ظهور الكوكب وخفاؤه 28 هو من تحت شعاع الشمس اما بالغدوات واما بالعشيات
- نز صعود الكوكب هو اما الى الاوج واما الى الذروة من فلك الندوير وهبوطها هو من احد هذين الموضعين
- نح الميل الاول الجزئي²⁹ قطعة قوس من دائرة تمر بقطبى معدل النهار ما بين فلك البروج ومعدل النهار النهار
- $\overline{\mathbf{d}}$ الميل الثاني الجزئي 30 قطعة قوس من دائرة تمر بقطبى فلك البروج 31 ما بين معدل النهار وفلك البروج
- س الميل الكلي في الميلين قطعة قوس من دائرة تمر باقطاب الدائرتين ما بين فلك البروج ومعدل النهار
 - سا مواضع خط الاستواء هي الدائرة التي على بسيط الارض في سطح معدل النهار
- سب مطالع خط الاستواء هو ما يطلع من معدل النهار مع قوس من فلك البروج في مواضع خط الاستواء وهو قوس من دائرة معدل النهار تحويها دائرتان تخرجان من 32 قطب معدل النهار وتمران بطرفى القوس من فلك البروج

الجزوي M (29

²⁷ C presents the entry as عرض القمر والكواكب العلوية ("latitude of the moon and the superior planets"), and then adds three extra entries (not found in other mss.) for the first, second and third latitudes of Venus and Mercury (see Commentary).

خفاه M خفاه

الجزوى M الجزوى

³¹ M add. و

³² M om.

- سَج عكس المطالع قوس من معدل النهار بين دائرتين تمران بقطب فلك البروج وبطرفى القوس منه و هو عكس مطالع القوس الواقعة من فلك البروج فيما بين هاتين الدائرتين
- سد بعد الكوكب عن معدل النهار قوس من الدائرة المارة بقطبى معدل النهار ما بين الكوكب ودائرة 33 معدل النهار
- سه عرض البلد قوس من دائرة نصف النهار ما بين سمت الرأس ودائرة معدل النهار او ³⁴ ما بين قطب معدل النهار والافق
- سو سعة المشرق قوس من دائرة الافق ما بين مطلع الاعتدال ومطلع الشمس او الكوكب يومئد سر تعديل نهار الجزء ³⁵ من فلك البروج هو الفضل بين مطالع الجزء بخط الاستواء ومطالعه بالبلد وهو قوس من معدل النهار بين دائرتين تمران بالجزء احديهما ³⁶ من قطب اول السموت والاخرى من قطب معدل النهار
- سح تعديل نهار الكوكب قوس من معدل النهار بين دائرتين تمران بالكوكب احديهما من قطب اول السموت و الاخرى من قطب معدل النهار
- سط مطالع البلد هو ما يطلع من معدل النهار مع قوس من فلك البروج في ذلك الافق وهو قوس من معدل النهار بين³⁷ دائرتين تخرجان من قطب اول السموت وتمران بطرفى القوس من فلك البروج عند عاية ارتفاع الشمس او الكوكب قوس من دائرة نصف النهار ما بين الافق وبين الشمس او الكوكب
 - عا دوائر المدارات 38 هي الموازية لمعدل النهار مخطوطة على قطبيه وبابعاد مختلفة
- عب نصف قوس نهار الشمس او الكوكب قوس من دائرة المدار ما بين الافق ونصف النهار ومقدارها القوس الشبيهة بها من معدل النهار والشبيهة هي القوس الواقعة بين قوسين يخرجان من قطب الكرة
 - عج الساعات المستوية هي ³⁹ ما يقسم قوس النهار على خمسة عشر
 - عد اجزاء الساعات الزمانية هي ما يقسم قوس النهار على اثنى عشر

دائر ة. M om

³⁴ M و

⁽also in the following occurrences) الجزؤ

⁽also in the following occurrence) احداهما

من M من

المدار M ³⁸

³⁹ F هو

- عه درجة ممر الكوكب هي النقطة التي يتقاطع عليها دائرة فلك البروج والدائرة المارة بقطبي معدل النهار والكوكب
- عو درجة طلوع الكوكب هي النقطة التي من فلك البروج تمر بها وبالكوكب جميعاً نصف دائرة الافق الشرقي
 - عز درجة الغروب هي النقطة التي من فلك البروج تمر بها وبالكوكب نصف دائرة الافق الغربي
 - عح ارتفاع الوقت قوس من دائرة الارتفاع ما بين الافق والكوكب
- عط الدائر من الفلك قوس من دائرة المدار ما بين الافق والشمس او الكوكب عند القياس و هو قطعة من قوس النهار
- $\overline{\Phi}$ سهم Φ^{4} قوس النهار هو الفصل المشترك بين نصف دائرة نصف النهار وبين قطعة دائرة المدار التي فوق الارض
- قا جيوب ترتيب الدائر 41 هي الفصول المشتركة بين قطعة دائرة المدار التي فوق الارض وبين انصاف الدوائر الموازية لدائرة نصف النهار
 - فب الطالع هو النقطة التي من فلك البروج على الافق الشرقي عند القياس
- فَجَ تسوية البيوت هي قسمة دائرة فلك البروج باثنى عشر قسماً⁴² كل قسم منها يجوز دائرة نصف النهار في ساعتين زمانيتين
 - فد بهت الكوكب هو مسيره الحقيقي في يوم او ساعة
 - فه سبق القمر هو فضل بهته على بهت الشمس
 - فو قطر النيرين هو قطر دائرة صفحتهما المرئية ويسمى مقدار الفلك ايضاً
- فر قطر الظل هو ⁴³ قطر اوسع دائرة تقع في مخروط ظل الارض حيث يجوز به القمر ويسمى فلك الجوز هر
- فح الاجتماع هو ان يكون مركز الارض ومركز القمر ومركز الشمس في سطح دائرة واحدة وتلك الدائرة تمر بقطبي فلك البروج
- فط الاجتماع الكسوفي هو ان يكون جرم القمر وجرم الشمس على الخط الذي يمر من البصر 44 البهما

نصف .F add

⁴¹ M om.

باقسام اثنی عشر M

⁴³ F om.

الابصار M 44

- ص الاستقبال ان يكون مركز الشمس ومركز الارض ومركز القمر في سطح دائرة تمر بقطبى فلك البروج
 - صا الاستقبال الخسوفي هو ان يكون هذه المراكز الثلثة او الاجرام على خط واحد مستقيم
 - صب خسوف القمر هو وقوعه في مخروط ظل الارض
 - صبح دقائق الخسوف هو ما يستتر من قطر دائرة صفحة القمر
 - صد اصابع الخسوف هو ما يستتر من قطره على ان القطر اثنى عشر اصبعاً
 - صه الاصابع المعدلة 45 هو ما يستتر من صفحته على ان مساحة صفحته 46 اثنا عشر اصبعاً
- صو ازمان الخسوف خمسة بدو الخسوف وبدو المكث وتمام الخسوف وهو حقيقة الاستقبال المسمى وسط الخسوف وبدو الانجلاء وتمام الانجلاء
- $\overline{\text{صر }}$ دقائق السقوط قوس 47 من الفلك المائل ما 48 بين بدو الخسوف وتمامه وما بين تمام الخسوف وتمام الانجلاء
 - صح الازمان المعدلة هي هذه الازمنة معدلة بحسب عرض القمر في كل زمان
- صط بعد النيرين من الارض هو الخط الواصل بين مركز الارض او سطحها⁴⁹ وبين القمر او الشمس
- $\overline{\overline{g}}$ اختلاف المنظر هو \overline{g} قوس من دائرة الارتفاع ما بين موضع الكوكب بالقياس الى مركز الارض وبين موضعه بالقياس الى سطح الارض
- قا الزوايا الست التي تحتاج اليها في الكسوفات الشمسية هي⁵¹ زوايا تحدث عن تقاطع فلك البروج ودائرة الارتفاع عند درجة القمر والمطلوب من كل تقاطع احدى الزاويتين الشماليتين التي هي اصغر من قائمة وهي زاوية العرض وتمامها من تسعين زاوية الطول

⁴⁵ This entry is missing in F, so the order numbers of the consequent entries in F are one less than the corresponding numbers in M which we quote here.

اصنعه M

⁴⁷ M om.

⁴⁸ M om.

⁴⁹ M سطحه

⁵⁰ M om.

⁵¹ M om.

 $\frac{52}{6}$ اختلاف المنظر في الطول هو ما بين موضع القمر المقوم من فلك البروج وبين $\frac{52}{6}$ موضعه المرئى منه

- قَج اختلاف المنظر في العرض هو ما بين عرض القمر الحقيقي وبين عرضه المرئي من دائرة تمر بقطبي فلك البروج
- قد العرض المرئي قوس من دائرة تمر بقطبي فلك البروج ما بين موضع القمر المرئي من دائرة الارتفاع وبين دائرة فلك البروج
 - قه كسوف الشمس هو استتارها بالقمر
 - قو ازمان الكسوف ثلثة بدو الكسوف وتمام الكسوف وهو وسطه وحقيقة الاجتماع وتمام الانجلاء
 - قر الازمان المعدلة هي هذه الازمنة الثلثة معدلة بحسب عرض القمر
- قح قوس الرؤية قوس من دائرة الارتفاع ما بين الافق والكوكب عليه وبين الشمس تحت الارض وان اخذت هذه القوس من دائرة الارتفاع ما بين الكوكب فوق الارض وبين الافق والشمس عليه كان جائزاً
- \overline{ad} بعد درجة الكوكب من الاوتاد ساعات زمانية بين 53 درجة الكوكب والوتد المأخوذ منه البعد \overline{a} مطرح الشعاع بدرج السواء قسي مأخوذة من فلك البروج 54 ان لم يكن للكوكب عرض وان كان له عرض فمن دائرة تمر بجرم الكوكب ومقاديرها من عند درجة الكوكب الي التوالي ستون وتسعون ومائة وعشرون ومائة 55 وثمانون
- قياً مطرح الشعاع بدرج المطالع هو تسوية البيوت على ان اقيم درجة الكوكب هنا مقام الطالع هناك ويكون التسوية بمطالع افق موضع الكوكب
- قيب افق موضع الكوكب هي الدائرة التي تمر بالكوكب وبتقاطع دائرة نصف النهار ودائرة الافق قيج التسيير هو بلوغ الدرجة المتأخرة في الطلوع الى موضع الدرجة المتقدمة في الطلوع بدور الكل على ان كل درجة بينهما بمطالع موضع 56 الدرجة المتقدمة سنة او شهر او يوم
- قيد تحويل السنة هو عودة الشمس الى موضعها الاصلي وذلك في كل ثلثمائة وخمسة وستين يوماً وخمس ساعات وست واربعين دقيقة واربع وعشرين ثانية من ساعة

ين . F om. بين

⁵³ M من

⁵⁴ M add. و

ثمانية F

بمطالع موضع instead of مطالع

قيه الارتفاع الذي لا سمت له قوس من دائرة الارتفاع المارة بالشمس او الكوكب وبمطلع⁵⁷ الاعتدال

قيو سمت الارتفاع قوس من دائرة الافق ما بين مطلع الاعتدال وموقع دائرة الارتفاع من الافق

 $\frac{1}{6}$ قوس من الدائرة الافق ما بين $\frac{59}{6}$ فلك البروج ودائرة الارتفاع

قيح حصة السمت هو الخط الخارج من موقع العمود الخارج من جرم الشمس عموداً على الفصل المشترك بين 60 دائرة المدار والافق

قيط تعديل السمت 61 هو هذا الخط عموداً على الفصل المشترك بين معدل النهار والافق

قك حصة الارتفاع قوس من دائرة الارتفاع ما بين تقاطعها لمعدل النهار وبين الافق

 $\overline{\text{EDI}}$ تعديل الارتفاع 62 قوس من دائرة الارتفاع ما بين تقاطعها لمعدل النهار وبين دائرة المارة بقطبى معدل النهار و بجرم الشمس

 $\overline{62}$ حصة الدائر $\overline{63}$ قوس من معدل النهار ما بين الافق ودائرة الارتفاع

قكج تعديل الدائر قوس من معدل النهار ما بين دائرة الارتفاع والدائرة المارة بقطبي معدل النهار وبجرم 64 الشمس

قكد خط نصف النهار هو الفصل المشترك بين سطح دائرة نصف النهار وسطح دائرة الافق

قكه انحراف البلدان وسمتها قوس من دائرة الافق ما بين دائرة نصف النهار ودائرة الارتفاع المارة بسمت رؤوسنا ورؤوس اولئك

قكو ما بين عرض البلدين قوس من دائرة نصف النهار ما بين سمت رؤوسنا وبين الدائرة المخطوطة على قطب معدل النهار وببعد وتر عرض اولئك وقد تقدم ان ما بين الطولين قوس من معدل النهار ما بين دائرتي نصف نهار المدينتين

قكز البعد بين البلدين قوس من دائرة الارتفاع بين سمت رؤوسنا ورؤوس اولئك

الكوكب وبمطلع instead of بالكوكب ومطلع M

المطالع F المطالع

الدائرة الافق ما بين instead of دائرة M

⁶⁰ M نم

⁶¹ F provides this entry at the end of the previous one; so the order numbers of the consequent entries in F are two less than the corresponding entries in M which we quote here.

⁶² M add. هه

الدائرة F الدائرة

بجزؤ M 64

 $\overline{62}$ تعديل الطول قوس من دائرة تمر بمطلع 65 اعتدالنا وسمت 66 رؤوس اولئك $\overline{62}$ قوس من دائرة نصف النهار ما بين دائرة تعديل الطول 67 وبين معدل النهار $\overline{60}$ عرض البلد المعدل قوس من 68 دائرة نصف النهار ما بين سمت رؤوسنا وبين دائرة تعديل الطول

 $\overline{\text{BK}}$ الكواكب الثابتة هي التي سوى السبعة السيارة وليست بالحقيقة ثابتة لكن حركاتها بالاضافة الى حركات السيارة بطيئة جداً وايضاً فلان كل كوكب منها لازم لدائرة من الدوائر الموازية لمنطقة فلك البروج لايزول عنها فلا يختلف عرضه سميت ثابتة وذلك ما اردنا ان نذكر 69 في هذا الباب

⁶⁵ M om.

بسمت M ف

الطولين M 67

فى M فى

⁶⁹ M نذکر ه