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## **Kūshyār ibn Labbān's Glossary of Astronomy**

Mohammad Bagheri

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## 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-Zīj al-Jāmi'* (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 Miqāt 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 Tirmāh 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 to make it sure for myself that one may not rely on observational *zīj*es. Because if they turn out to be correct in one <case> by some tricks, they are erroneous in ten <cases>. 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.<sup>1</sup>

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قال كوشيار قران المريخ وزحل برأى العين عشية يوم الخميس الحادى والعشرين من تيرماه سنة اثنين وستين<sup>1</sup> وثلاثمائة ليزدجرد فقومتها لنصف النهار فكان زحل في الحوت . نط المريخ فيه ان في اول رجوعه بنقصان درجتين من وسطه وزيادة 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 بخطه

## Translation

A Special Chapter on the Generalities of the Science of Cosmology

1. **Era** (*al-tā'rikh*): A known day to which the time which has passed is referred.
2. **Circle** (*al-dā'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-quṭr*): 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'kūs*): 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-miqyās*): 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 6 1/2 <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)** (*quṭr 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-dawā'ir al-'iẓām*): <The circles> whose planes pass through the center of the sphere and cut <the sphere> into two halves.

**14. Circle of the equator** (*dā'irat mu'addil al-nahār*): <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** (*dā'irat falak al-burūj*): <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** (*dā'irat al-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** (*dā'irat al-niṣf al-nahār*): <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** (*dā'irat al-irtifā'*): <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. Porecliptic orb in any sphere** (*al-falak al-mumaththil fī kull kura*): A circle in the plane of the ecliptic and <centered> at its center.

**22. Inclined orb in any sphere** (*al-falak al-mā'il fī 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 porecliptic orb.

**24. Epicycles** (*aflāk al-tadāwīr*): Small circles whose centers <are> on the circumferences of the eccentric orbs.

**25. Mean longitude of the sun** (*wasat 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** (*khāṣṣat 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'dīl 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-wasat*): <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-ḥaqīqī*): <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'dīl al-ayyām bi-layālīhā*): <The summation of> the difference between the mean day and the true day.

**33. <Geographical> longitude of <any> locality** (*tūl 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” (*mā bayn al-tūlayn*).

**34. Mean longitude of the moon** (*wasat 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** (*khāṣṣat al-qamar*): Its distance from the apogee of the epicycle <counted> in the opposite order <of the zodiacal signs>.

**36. Double elongation <of the moon>** (*al-bu'd al-mudā'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-tadwīr wa'l-khāṣṣat 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'dīl al-thānī*): 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** (*ikhṭilāf*): 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** (*daqā'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** (*taqwīm 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)** (*wasat 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)** (*khāṣṣat 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'dīl al-thānī*): An angle <with its vertex> at the center of the parecliptic orb constructed 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** (*ikhtilāf*): 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** (*hiṣṣat al-'ard*): 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-rujū'*): An arc of the epicycle between the two stations closer to the perigee.

**56. Apparition and occultation of a star (i.e., planet)** (*zuhūr 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)** (*ṣu'ūd al-kawkab*): Either <the star (i.e., planet)'s motion> towards the apogee or towards the perigee of the epicycle, and its descension (*hubūt*) 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-thānī al-juz'ī*): 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-kullī fī'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 <terrestrial> equator line** (*mawāḍi' khatt al-istiwā'*): The circle on the earth's surface in the plane of the equator.

**62. Right ascension (Ascensions <at> the equator line)** (*maṭāli' khatt al-istawā'*): <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-nahār*): An arc of the <great> 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** (*'arḍ 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).

**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 <given> part (i.e., degree) of the ecliptic** (*ta'dīl nahār al-juz' min falak al-burūj*): The difference between the right ascension of the <ecliptical> degree and its oblique ascension (see no. 69). It is an arc of the equator between two circles that pass through the <given ecliptical> degree, one of which <is drawn> from the pole of <the circle of> 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'dīl nahār al-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** (*maṭāli' 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** (*ghāyat irtifā' al-shams aw al-kawkab*): An arc of the meridian circle between the horizon and the sun or the star.

**71. Parallel circles** (*dawā'ir al-madārāt*): <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** (*nişf 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-sā'āt al-mustawīya*): It is <obtained> by dividing the day arc by 15 <degrees>.

**74. <Number of> the parts (i.e., degrees) in seasonal hours** (*ajzā' al-sā'āt al-zamānīya*): It is <obtained> by dividing the day arc by 12 <hours>.

**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 ṭulū' 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. <Ecliptical> degree of the setting <of a star>** (*darajat al-ghurūb*): The point of the ecliptic orb <such> that the semi-circle of the western horizon passes through it and the star <simultaneously>.

**78. Altitude of <a star at a given> time** (*irtifā' 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-nahār*): 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** (*ju'yūb tartīb al-dā'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-ṭāli'*): The point of the ecliptic which is on the eastern horizon at <the time of> measurement.

**83. Equalization of houses** (*taswiyat al-buyūt*): 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** (*quṭr 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** (*quṭr 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-ijtimāʿ*): <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-ijtimāʿ al-kusūfī*): <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-istiqbāl*): <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-istiqbāl al-khusūfī*): <The situation> that these three centers (mentioned above) or the <three> bodies <lie> on a single straight line.

**92. Lunar eclipse** (*khusūf 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** (*daqāʿiq al-khusūf*): <The portion> of the diameter of the circle of the moon’s <apparent> surface which is covered <by the earth’s shadow>.

**94. <Magnitude of a> lunar eclipse in digits** (*aṣābiʿ al-khusūf*): 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** (*azmān al-khusūf*): <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** (*daqā'iq al-suqūt*): 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-manẓar*): 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 tahtāj 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** (*ikhtilāf al-manẓar fī'l-ṭūl*): <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-manẓar 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-'arḍ al-mar'ī*): 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** (*kusūf al-shams*): Its coverage by the moon.

**106. The times of a solar eclipse** (*azmān al-kusūf*): <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 <ecliptical> degree of a star (i.e., planet) from the cardines** (*bu'd darajat al-kawkab min al-awtād*): <The distance in terms of> 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, <in terms of> seasonal hours.

**110. Projection (Casting) of the ray by means of equal (i.e., ecliptical) degrees** (*maṭraḥ al-shu'ā' bi-daraj al-sawā'*): 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** (*maṭraḥ al-shu'ā' bi-daraj al-maṭāli'*): 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 mawḍi' 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-tasyīr*): 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-irtifā' alladhī lā 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-irtifā'*): 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-tāli'*): An arc of the horizon circle between the ecliptic orb and the altitude circle.

**118. Argument of the azimuth** (*hiṣṣat 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'dīl 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** (*hiṣṣat al-irtifā'*): An arc of the altitude circle between its intersection with the equator and the horizon.

**121. Equation of altitude** (*ta'dīl al-irtifā'*): 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** (*hiṣṣat al-dā'ir*): An arc of the equator between the horizon and the altitude circle.

**123. Equation of the arc of revolution** (*ta'dīl al-dā'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** (*khattī niṣf al-nahār*): 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'** (*inḥirāf al-buldān wa-samtuhā*): 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** (*mā bayn 'arḍ al-baladāyn*): 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 <geographical> longitude** (*ta'dīl al-tūl*): An arc of the circle that passes through the equinoctial rising point <of the sun> for us (i.e., the east point on the horizon) and the zenith of those <localities>.

**129. Equation of <geographical> latitude** (*ta'dīl al-'arḍ*): An arc of the meridian circle between the circle of the equation of <geographical> 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

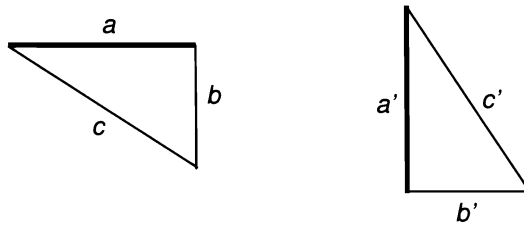
In the text of *ZJ*, Kūshyār uses the term *ta'rīkh* (no. 1) for “era”, “epoch” and “calendar” in different contexts (e.g., in Chapters 1 and 2 of the first section of Book I).

In no. 6, Kūshyār defines the terms such that *al-jayb al-ma'kūs* (“Versed Sine”) of an arc  $\alpha$  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 *zīj* (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’kūs* (“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).

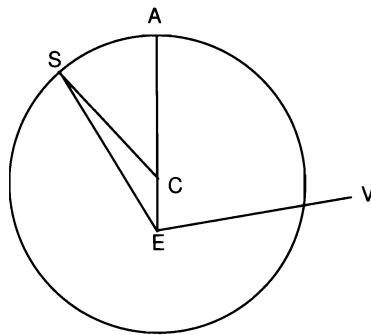


*Quṭr al-zill* (no. 11) of an arc  $\alpha$  is equivalent to  $60 \sec \alpha$  or  $60 \csc \alpha$  in modern notation depending on using a horizontal or vertical gnomon. Kūshyār mentions the same term in no. 87, but in the literal meaning “diameter of the shadow [of the earth]”.

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-burūj*) may also refer to the “sphere of the fixed stars”. Al-Kāshī used *falak al-burūj* 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 precliptic 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 *zuhūr* ("apparition") and *khafā'* ("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-ḥadīd* ("perigee"), *al-falak al-mu'addil li'l-masīr* ("equant orb"), *al-'arḍ al-awwal* ("first latitude"), *al-'arḍ al-thānī* ("second latitude"), *al-'arḍ al-thālith* ("third shadow"), *irtifā' quṭb falak al-burūj* ("altitude of the ecliptic orb") also called '*arḍ iqlīm al-ru'ya*' ("latitude of the clime of visibility"), *irtifā' al-qamar bi-ḥasab 'arḍihi* ("altitude of the moon taking account of its latitude"), *sā'āt al-taqwīm* ("hours of the true longitude"), *sā'āt al-tahwīl* ("hours of transfer"), and *manāzil al-qamar* ("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

- أ التاريخ يوم معلوم ينسب اليه زمان يأتي عليه
- ب الدائرة سطح يحيط به خط واحد في داخله نقطة كل الخطوط المستقيمة الخارجة من تلك النقطة الي المحيط متساوية وتلك النقطة مركز الدائرة
- ج القطر هو الخط المستقيم الواصل بين طرفي قوس نصف الدائرة فبالاضطرار يمر بمركز الدائرة
- د الوتر هو الخط المستقيم الواصل بين طرفي قوس بعض الدائرة
- ه 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
- و الجيب المعكوس قطعة من القطر ما بين طرف القوس وجيبه وهو ايضاً سهم ضعف القوس
- ز المقياس شخص مستو اما قائم على سطح<sup>1</sup> الافق واما مواز لسطح الافق فاما ان يقسم باثنى عشر ويسمى اصابعاً واما ان يقسم بسبعة او بستة ونصف ويسمى اقداماً واما ان يقسم باقسام آخر فيستعمل ظله في وجوه من الاعمال
- ح الظل الاول لكل قوس هو المأخوذ من المقاييس الموازية لسطح الافق وهو خط يخرج من اصل المقياس موازياً لجيب القوس
- ط الظل الثاني لكل قوس هو المأخوذ من المقاييس القائمة على سطح الافق وهو خط يخرج من اصل المقياس موازياً لجيب تمام القوس
- ي قوس الظل هي<sup>3</sup> 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

<sup>1</sup> السطح M

<sup>2</sup> يكون M add.

<sup>3</sup> M om.

يد دائرة معدل النهار هي المخطوطة على قطب كرة الكل ويبعد وتر ربع دائرة عظيمة  
 به 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 الخفي وقطبها سمت الرأس  
 يز دائرة نصف النهار هي التي قطبها مطلع الاعتدال ومغيبه وتقطع دائرة الافق على زوايا قائمة  
 يح دائرة الارتفاع هي التي تمر بسمت الرأس وبالكوكب المفروض  
 يط الافلاك تسعة سبعة للكواكب السيارة وثامنها<sup>4</sup> للكواكب الثابتة والتاسع المتحرك المحرك<sup>5</sup> لهذه  
 كلها

ك كرة كل كوكب هي التي يتضمن جملة حركاته

كا الفلك الممثل في كل كرة هي دائرة في سطح دائرة البروج و<sup>6</sup> على مركزها  
 كب الفلك المائل في كل كرة هي دائرة مركزها مركز فلك البروج وسطحها مائل عن سطحها  
 كج الافلاك الخارجة المراكز دوائر في سطوح الافلاك المائلة ومراكزها خارجة عن مركز الفلك  
 المائل وللشمس في سطح الفلك الممثل

كد افلاك التدوير 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

كو الاوج<sup>7</sup> ابعده موضع على محيط الفلك الخارج المركز من مركز<sup>8</sup> فلك البروج  
 كز خاصة الشمس قوس من الفلك الممثل ما بين الاوج والخط الخارج الى الشمس من مركز الفلك  
 الخارج المركز

كح تعديل الشمس زاوية عند جرم الشمس على محيط الفلك الخارج المركز ترسم من خطين  
 يخرجان من مركز الفلك الممثل ومركز الفلك<sup>9</sup> الخارج المركز  
 كط تقويم الشمس قوس من الفلك الممثل ما بين اول الحمل والخط الخارج من مركز فلك البروج  
 الى الشمس

<sup>4</sup> M و ثامنه

<sup>5</sup> M التاسعة المتحركة المحركة

<sup>6</sup> F om.

<sup>7</sup> M add. هو

<sup>8</sup> M om.

<sup>9</sup> F add. superfluous الفلك

لَ **اليوم الوسط**<sup>10</sup> هو دور واحد لمعدل النهار من نصف النهار الى نصف النهار وزيادة قوس منه مثل وسط الشمس ليوم<sup>11</sup>

لَا **اليوم الحقيقي** هو دور واحد لمعدل النهار كما قلنا وزيادة ما يجوز نصف النهار مع مسير الشمس المقوم

لَب **تعديل الايام بلياليها** هو الاختلاف بين اليوم الوسط واليوم الحقيقي

لَج **طول البلد** قوس من معدل النهار ما بين دائرة<sup>12</sup> نصف النهار المارة بأخر العمارة ودائرة نصف نهار البلد وما بين نصف نهار البلدين من معدل النهار<sup>13</sup> هو ما بين الطولين

لَد **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<sup>14</sup>المائل واحد<sup>15</sup>

لَه **خاصة القمر** بعده من ذروة فلك التدوير الى خلاف التوالي

لَو **البعد المضاعف**<sup>16</sup> قوس من الفلك الممثل ما بين موضع الاوج منه وبين السطح المار بمركز هذا الفلك ومركز فلك التدوير

لَز **التعديل الاول** زاوية عند مركز فلك التدوير ترسم<sup>17</sup> 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<sup>18</sup>

لَح **التدوير والخاصة المعدلة** قوس من فلك التدوير ما بين القمر والسطح الخارج من مركز<sup>19</sup> الفلك الممثل ماراً بمركز فلك التدوير

<sup>10</sup> M الوسطى

<sup>11</sup> M om.

<sup>12</sup> M الدائرة

<sup>13</sup> M om. من معدل النهار

<sup>14</sup> M add. الفلك

<sup>15</sup> M واحدة

<sup>16</sup> M المضاعف

<sup>17</sup> M ترسم

<sup>18</sup> D and Y instead of ابواب الثلثين , L الابواب الثلثين found in F and M. However, the term *ta'dil al-awwal* (the first equation) is actually explained in Chapter 17 of Book III.

<sup>19</sup> F om.

لَطَ **التعديل الثاني** زاوية عند مركز الفلك الممثل ترسم<sup>20</sup> من خطين يخرجان من هذا المركز الى مركز فلك التدوير والى<sup>21</sup> جرم القمر

مَ **الاختلاف** هو اختلاف نصف قطر فلك التدوير بين ما يرى عند بعده الابعد وما يرى عند بعده الاقرب

مَ **دقائق النسب** عددٌ نسبته الى ستين دقيقة كنسبة الاختلاف اللازم حيث مركز فلك التدوير الى كل الاختلاف في ذلك الموضع

مَبَ **تقويم القمر** قوس من الفلك الممثل ما بين اول الحمل والسطح المار<sup>22</sup> بمركز هذا الفلك وبجرم القمر

مَجَ **الجوزهر** هو العقديتان الحادثتان عن تقاطع الفلك المائل و<sup>23</sup> الممثل في كل كوكب

مَدَ **وسط الكوكب** قوس من الفلك الممثل بين سطحين يمران بمركز الفلك المعدل للمسير يمر احدهما<sup>24</sup> باول الحمل والآخر بمركز فلك التدوير

مَهَ **خاصة الكوكب** بعده من ذروة فلك التدوير الى التوالي

مَوَ **المركز** قوس من الفلك الممثل بين سطحين يمران بمركز الفلك المعدل ينتهي احدهما<sup>25</sup> الى الاوج والآخر الى مركز فلك التدوير

مَزَ **التعديل الاول** زاوية عند مركز فلك التدوير ترسم من خطين يخرجان من مركز الفلك الممثل ومركز الفلك المعدل للمسير

مَحَ **التدوير والخاصة المعدلة** قوس من فلك التدوير بين سطحين يمران بمركز الفلك التدوير<sup>26</sup> فيمر احدهما بذروة فلك التدوير والآخر بالكوكب

مَطَ **المركز المعدل** قوس من الفلك الممثل بين سطحين يمران بمركز الفلك الممثل فيمر احدهما بالاوج والآخر بمركز فلك التدوير

نَ **التعديل الثاني** زاوية عند مركز الفلك الممثل ترسم من خطين يخرجان منه الى مركز فلك التدوير والى جرم الكوكب

<sup>20</sup> M ترسم

<sup>21</sup> M om. الى

<sup>22</sup> M المار الذي instead of يمر

<sup>23</sup> M add. الفلك

<sup>24</sup> M احدهما

<sup>25</sup> M احدهما

<sup>26</sup> In all mss. الممثل instead of التدوير which is the correct word in the context

نَا الاختلاف هو اختلاف نصف قطر فلك التدوير بين ما يرى عند البعد الاوسط وما يرى عند البعد  
الابعد والاقرب

نَب تقويم الكوكب قوس من الفلك الممثل بين سطحين يمران بمركزه فيمر احدهما باول الحمل  
والآخر بجرم الكوكب

نَج حصّة العرض هي بعد القمر والكوكب من العقدة الشمالية التي يسمى الرأس

نَد العرض<sup>27</sup> قوس من دائرة عظيمة تمر بقطبي فلك البروج ما بين الكوكب وفلك البروج

نِه قوس الرجوع قوس من فلك التدوير ما بين وقفتي الكوكب مما يلي الحضيض

نَو ظهور الكوكب وخفاؤه<sup>28</sup> هو من تحت شعاع الشمس اما بالغدوات واما بالعشيات

نَز صعود الكوكب هو اما الى الاوج واما الى الذروة من فلك التدوير وهبوطها هو من احد هذين  
الموضعين

نَح الميل الاول الجزئي<sup>29</sup> قطعة قوس من دائرة تمر بقطبي معدل النهار ما بين فلك البروج ومعدل  
النهار

نَط الميل الثاني الجزئي<sup>30</sup> قطعة قوس من دائرة تمر بقطبي فلك البروج<sup>31</sup> ما بين معدل النهار وفلك  
البروج

س الميل الكلي في الميلين قطعة قوس من دائرة تمر باقطاب الدائرتين ما بين فلك البروج ومعدل  
النهار

سَا مواضع خط الاستواء هي الدائرة التي على بسيط الارض في سطح معدل النهار

سَب 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<sup>32</sup> قطب معدل النهار وتمران  
بطرفي القوس من فلك البروج

<sup>27</sup> 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).

<sup>28</sup> M خفاء

<sup>29</sup> M الجزوي

<sup>30</sup> M الجزوي

<sup>31</sup> M add. و

<sup>32</sup> M om.



سج عكس المطالع قوس من معدل النهار بين دائرتين تمران بقطب فلك البروج وبطرفي القوس منه وهو عكس مطالع القوس الواقعة من فلك البروج فيما بين هاتين الدائرتين

سد بعد الكوكب عن معدل النهار قوس من الدائرة المارة بقطبي معدل النهار ما بين الكوكب ودائرة<sup>33</sup> معدل النهار

سه عرض البلد قوس من دائرة نصف النهار ما بين سمت الرأس ودائرة معدل النهار او<sup>34</sup> ما بين قطب معدل النهار والافق

سو سعة المشرق قوس من دائرة الافق ما بين مطلع الاعتدال ومطلع الشمس او الكوكب يومئذ

سز تعديل نهار الجزء<sup>35</sup> من فلك البروج هو الفضل بين مطالع الجزء بخط الاستواء ومطالعه بالبلد وهو قوس من معدل النهار بين دائرتين تمران بالجزء احديهما<sup>36</sup> 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 والاخرى 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 بين<sup>37</sup> دائرتين تخرجان من قطب اول السموت وتمران بطرفي القوس من فلك البروج

ع غاية ارتفاع الشمس او الكوكب قوس من دائرة نصف النهار ما بين الافق وبين الشمس او الكوكب

عا دوائر المدارات<sup>38</sup> 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<sup>39</sup> ما يقسم قوس النهار على خمسة عشر

عد اجزاء الساعات الزمانية هي ما يقسم قوس النهار على اثني عشر

<sup>33</sup> دائرة. M om.

<sup>34</sup> M و

<sup>35</sup> M الجزء (also in the following occurrences)

<sup>36</sup> M احدهما (also in the following occurrence)

<sup>37</sup> M من

<sup>38</sup> M المدار

<sup>39</sup> F هو

ع<sup>ه</sup> درجة ممر الكوكب هي النقطة التي يتقاطع عليها دائرة فلك البروج والدائرة المارة بقطبي معدل النهار والكوكب

ع<sup>و</sup> درجة طلوع الكوكب هي النقطة التي من فلك البروج تمر بها وبالكوكب جميعاً نصف دائرة الافق الشرقي

ع<sup>ز</sup> درجة الغروب هي النقطة التي من فلك البروج تمر بها وبالكوكب نصف دائرة الافق الغربي

ع<sup>ح</sup> ارتفاع الوقت قوس من دائرة الارتفاع ما بين الافق والكوكب

ع<sup>ط</sup> الدائر من الفلك قوس من دائرة المدار ما بين الافق والشمس او الكوكب عند القياس وهو قطعة من قوس النهار

ف<sup>س</sup> سهم<sup>40</sup> قوس النهار هو الفصل المشترك بين نصف دائرة نصف النهار وبين قطعة دائرة المدار التي فوق الارض

ف<sup>ا</sup> جيوب ترتيب الدائر<sup>41</sup> هي الفصول المشتركة بين قطعة دائرة المدار التي فوق الارض وبين انصاف الدوائر الموازية لدائرة نصف النهار

ف<sup>ب</sup> الطالع هو النقطة التي من فلك البروج على الافق الشرقي عند القياس

ف<sup>ج</sup> تسوية البيوت هي قسمة دائرة فلك البروج باثني عشر قسماً<sup>42</sup> كل قسم منها يجوز دائرة نصف النهار في ساعتين زمانيتين

ف<sup>د</sup> بهت الكوكب هو مسيره الحقيقي في يوم او ساعة

ف<sup>ه</sup> سبق القمر هو فضل بهته على بهت الشمس

ف<sup>و</sup> قطر النيرين هو قطر دائرة صفحتهما المرئية ويسمى مقدار الفلك ايضاً

ف<sup>ز</sup> قطر الظل هو<sup>43</sup> قطر اوسع دائرة تقع في مخروط ظل الارض حيث يجوز به القمر ويسمى فلك الجوزهر

ف<sup>ح</sup> الاجتماع هو ان يكون مركز الارض ومركز القمر ومركز الشمس في سطح دائرة واحدة وتلك الدائرة تمر بقطبي فلك البروج

ف<sup>ط</sup> الاجتماع الكسوفي هو ان يكون جرم القمر وجرم الشمس على الخط الذي يمر من البصر<sup>44</sup> اليهما

<sup>40</sup> F add. نصف

<sup>41</sup> M om.

<sup>42</sup> M باقسام اثني عشر

<sup>43</sup> F om.

<sup>44</sup> M الابصار

ص الاستقبال ان يكون مركز الشمس ومركز الارض ومركز القمر في سطح دائرة تمر بقطبي  
فلك البروج

صا الاستقبال الخسوفي هو ان يكون هذه المراكز الثلاثة او الاجرام على خط واحد مستقيم

صب خسوف القمر هو وقوعه في مخروط ظل الارض

صج دقائق الخسوف هو ما يستتر من قطر دائرة صفحة القمر

صد اصابع الخسوف هو ما يستتر من قطره على ان القطر اثني عشر اصبعاً

صه الاصابع المعدلة<sup>45</sup> هو ما يستتر من صفحته على ان مساحة صفحته<sup>46</sup> اثنا عشر اصبعاً

صو ازمان الخسوف خمسة بدو الخسوف وبدو المكث وتام الخسوف وهو حقيقة الاستقبال  
المسمى وسط الخسوف وبدو الانجلاء وتام الانجلاء

صز دقائق السقوط قوس<sup>47</sup> من الفلك المائل ما<sup>48</sup> بين بدو الخسوف وتامه وما بين تمام الخسوف  
وتام 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 سطحها<sup>49</sup> وبين القمر او  
الشمس

ق اختلاف المنظر هو<sup>50</sup> 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 هي<sup>51</sup> زوايا تحدث عن تقاطع فلك  
البروج ودائرة الارتفاع عند درجة القمر والمطلوب من كل تقاطع احدى الزاويتين الشمالييتين التي  
هي اصغر من قائمة وهي زاوية العرض وتامها من تسعين زاوية الطول

<sup>45</sup> 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.

<sup>46</sup> M اصبعه

<sup>47</sup> M om.

<sup>48</sup> M om.

<sup>49</sup> M سطحه

<sup>50</sup> M om.

<sup>51</sup> M om.

قَب اختلاف المنظر في الطول هو ما بين موضع القمر المقوم من فلك البروج وبين<sup>52</sup> موضعه المرئي منه

قَج اختلاف المنظر في العرض هو ما بين عرض القمر الحقيقي وبين عرضه المرئي من دائرة تمر بقطبي فلك البروج

قَد العرض المرئي قوس من دائرة تمر بقطبي فلك البروج ما بين موضع القمر المرئي من دائرة الارتفاع وبين دائرة فلك البروج

قَه كسوف الشمس هو استتارها بالقمر

قَو ازمان الكسوف ثلاثة بدو الكسوف وتام الكسوف وهو وسطه وحقيقة الاجتماع وتام الانجلاء

قَز الازمان المعدلة هي هذه الازمنة الثلاثة معدلة بحسب عرض القمر

قَح 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

قَط بعد درجة الكوكب من الاوتاد ساعات زمانية بين<sup>53</sup> درجة الكوكب والوتد المأخوذ منه البعد

قِي مطرح الشعاع بدرج السواء قسي مأخوذة من فلك البروج<sup>54</sup> 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<sup>55</sup> وثمانون

قِيَا مطرح الشعاع بدرج المطالع هو تسوية البيوت على ان اقيم درجة الكوكب هنا مقام المطالع هناك ويكون التسوية بمطالع افق موضع الكوكب

قِيَب افق موضع الكوكب هي الدائرة التي تمر بالكوكب ويتقاطع دائرة نصف النهار ودائرة الافق

قِيَج التسيير هو بلوغ الدرجة المتأخرة في الطلوع الى موضع الدرجة المتقدمة في الطلوع بدور الكل على ان كل درجة بينهما بمطالع موضع<sup>56</sup> الدرجة المتقدمة سنة او شهر او يوم

قِيَد 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

<sup>52</sup> F om. بين

<sup>53</sup> M من

<sup>54</sup> M add. و

<sup>55</sup> F ثمانية

<sup>56</sup> M بمطالع instead of موضع

قِيَهَ الارتفاع الذي لا سمت له قوس من دائرة الارتفاع المارة بالشمس او الكوكب وبمطلع<sup>57</sup>  
الاعتدال  
قِيَوَ سمت الارتفاع قوس من دائرة الافق ما بين مطلع الاعتدال وموقع دائرة الارتفاع من الافق  
قِيَزَ سمت من الطالع<sup>58</sup> قوس من الدائرة الافق ما بين<sup>59</sup> فلك البروج ودائرة الارتفاع  
قِيَحَ حصّة السمّت هو الخط الخارج من موقع العمود الخارج من جرم الشمس عموداً على الفصل  
المشترك بين<sup>60</sup> دائرة المدار والافق  
قِيَطَ تعديل السمّت<sup>61</sup> هو هذا الخط عموداً على الفصل المشترك بين معدل النهار والافق  
قَكَ حصة الارتفاع قوس من دائرة الارتفاع ما بين تقاطعها لمعدل النهار وبين الافق  
قَكَا تعديل الارتفاع<sup>62</sup> قوس من دائرة الارتفاع ما بين تقاطعها لمعدل النهار وبين دائرة المارة بقطبي  
معدل النهار وبجرم الشمس  
قَكَبَ حصة الدائر<sup>63</sup> قوس من معدل النهار ما بين الافق ودائرة الارتفاع  
قَكَجَ تعديل الدائر قوس من معدل النهار ما بين دائرة الارتفاع والدائرة المارة بقطبي معدل النهار  
وبجرم<sup>64</sup> الشمس  
قَكَدَ خط نصف النهار هو الفصل المشترك بين سطح دائرة نصف النهار وسطح دائرة الافق  
قَكَهَ انحراف البلدان وسمتها قوس من دائرة الافق ما بين دائرة نصف النهار ودائرة الارتفاع  
المارة بسمت رؤوسنا ورؤوس اولئك  
قَكَوَ ما بين عرض البلدين قوس من دائرة نصف النهار ما بين سمت رؤوسنا وبين الدائرة  
المخطوطة على قطب معدل النهار وبعده وتر عرض اولئك وقد تقدم ان ما بين الطولين قوس من  
معدل النهار ما بين دائرتي نصف نهار المدينتين  
قَكَزَ البعد بين البلدين قوس من دائرة الارتفاع بين سمت رؤوسنا ورؤوس اولئك

<sup>57</sup> M الكوكب وبمطلع instead of بالكوكب ومطلع

<sup>58</sup> F المطالع

<sup>59</sup> M الدائرة الافق ما بين instead of دائرة

<sup>60</sup> M من

<sup>61</sup> 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.

<sup>62</sup> M add. هو

<sup>63</sup> F الدائرة

<sup>64</sup> M بجزو

فَكَحَّ تَعْدِيلَ الطُّولِ قوس من دائرة تمر بمطلع<sup>65</sup> اعتدالنا وسمت<sup>66</sup> رؤوس اولئك  
فَكَطَّ تَعْدِيلَ العَرَضِ قوس من دائرة نصف النهار ما بين دائرة تعديل الطول<sup>67</sup> وبين معدل النهار  
قَلَّ عَرَضَ البَلَدِ المَعْدِلِ قوس من<sup>68</sup> دائرة نصف النهار ما بين سمت رؤوسنا وبين دائرة تعديل  
الطول  
قَلَّا 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<sup>69</sup> في هذا الباب

(Received: November 11, 2006)

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<sup>65</sup> M om.

<sup>66</sup> M بسمت

<sup>67</sup> M الطولين

<sup>68</sup> M في

<sup>69</sup> M نذكره

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