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Luhot Ha-Ibbur Part II: Rabbi Raphael ha-Levi from Hanover's Tables of Intercalation

Calculation of the Moon's Visibility According to Maimonides

The second part of Hanover's tables is devoted to the calculation of the moon's visibility according to the method adopted by Maimonides in his *Hilkhot Kiddush ha-Hodesh*. Hanover followed Ptolemy's methods of ancient astronomy and Maimonides' criterion of visibility. In contrast to Maimonides, who used simplified and approximate methods, Hanover tabulated – with great precision and exactitude – the true astronomical model of Ptolemy, corresponding to Maimonides' exact model.

As clearly stated by the author in the introduction, the book describes the method of calculation in great detail and precision, without giving any explanation or justification. The explanations, proofs and justifications of the described method were to be gathered in a third part of the book, which was never published.

In the present paper we explain the meaning of the different tables and we expound the formulas that enable their construction and accuracy.

It appears that Hanover was indeed the first to master completely the calculation of the moon's visibility according to Maimonides' astronomical model without any simplification or approximation.

INTRODUCTION

Understanding the astronomical chapters of the Rambam's *Hilkhot Kiddush ha-Hodesh* has always been a challenge for rabbis and scholars. One of the main difficulties was the concept of the arc of vision. In Greek astronomy, the arc of vision of a star is the depression of the sun at the time of the setting of this star.

The Arabic definition of the arc of vision or arc of light is the set lag between the heavenly body considered and the sun. It is measured by the arc of the celestial equator comprised between two points, the first setting together with the heavenly body being considered, in our case the apparent moon, the second setting together with the sun. The uncertainty about the meaning of the arc of vision has troubled the understanding of *Hilkhot Kiddush ha-Hodesh* and the definition of the four elongations necessary to calculate the arc of vision, on which depends the criterion of visibility of the new moon. The first commentary on *Hilkhot Kiddush ha-Hodesh (HKH)* was written by R. Obadiah ben David.[1] Despite this author's profound astronomical knowledge, he did not succeed in elucidating the subject completely because he adopted the Greek definition of the arc of vision. The second great commentator of *HKH* was R. Levi ben Haviv, who was thought to be the first to give the correct definition of the four elongations and the arc of vision. I have nevertheless shown that he was already preceded in this matter by R. Abraham Zacuto, the Spanish, and later Portuguese,[2] Royal Astronomer in his magnum opus.[3] It is also certain that R. Levi ben Haviv knew of this work,[4] and certainly acquired his knowledge from it. The glory of this discovery thus must be credited to Zacuto.

The interest in *HKH* in Eastern Europe began in the 16th century, when R. Mordecai Jaffe, after a stay in Venice in order to learn the subject, wrote *Levush Eder ha-Yakar*. In the 17th century, the scholar R. Yom Tov Lipmann Heller wrote a commentary, still in manuscript, aiming to explain and correct the extant commentaries. A century later, in 1720, R. Jonathan ben Joseph published a correct edition of *HKH* with the extant printed commentaries and the drawings belonging to them.

All these commentaries are nevertheless purely descriptive; they aim, with greater or lesser success, to explain Ptolemy's model and Maimonides' algorithm. They are heavy, long-winded, and difficult to understand. They don't try to quantify the mathematical model from which Maimonides departed to build his simplified model.

Hanover was the first scholar to propose a precise calculation of the moon's

1 In the 14th century.
2 Before leaving Western Europe for the Orient in 1496, concluding the scientific part of his life.
3 B. Cohn, *Abraham Zacuto: Almanach Perpetuum. Viertheljahrsschrift der astronomischen gesellschaft*, Jahrgang 52, 1917.
4 He mentions him and refers to this work in his commentary on chap. 17.

visibility according to the astronomical model used by Maimonides, without the simplifications and approximations made by Maimonides. This model is Ptolemy's model with slight numerical improvements made by Al-Battani. In his tables, Hanover adopted the assumption that the highest precision in the parameters adopted by Maimonides for the sun and the moon, especially the velocity of their variation, can be deduced from Maimonides' data for a span of time of 10,000 days. E. Baneth, at the beginning of the 20th century, still made the same assumption. This assumption leads to the surprising result that the values given by Hanover in the second part of his tables, according to the values of Maimonides and ancient astronomy, are better and more accurate than those given in the first part of his table, according to the more modern 18th-century astronomy.

I. ASTRONOMICAL TABLES ACCORDING TO MAIMONIDES

1. Glossary

אמצע השמש	Longitude of the mean sun.
אמצע הירח	Longitude of the mean moon.
גובה השמש	Longitude of the sun's apogee.
אמצע מסלול הירח	Moon's mean anomaly.
אמצע הראש	Longitude of the moon's ascending node, expressed by a negative figure and measured in the negative direction.
מנת מסלול השמש	Quota of the sun's anomaly or equation of the center.
מנת מרחק הכפול	Quota of the moon's double elongation.
נטייה	Declination.
נליזת הנטייה	Deviation or variation of the declination.
חלק היחוס	Proportion c.
רוחב הירח	Moon's latitude.
מסלול הרוחב	Argument of latitude = distance of the moon from the ascending node.
מסלול הנכון	True anomaly = mean anomaly +- p.
מנת מסלול הנכון	Quota of the true anomaly (angle q).
שינוי אלכסון	Angle s.
הבדל השקיעה	Difference of sunset.
עלייה ישרה	Right ascension.
מצעדי המזלות	Right ascension.
נליזת עלייה ישרה	Deviation of variation of the right ascension.

רוחב המדינה	Geographical latitude.
מנת המדינה	Geographical longitude.
רגע המוגבל	Moment adopted for performing the visibility calculations.

2. Astronomical Background

The following references should be consulted:

1. "The Equation of Time in Ancient Jewish Astronomy": J.J. Ajdler, *B.D.D.* 16, pp. 43-51.
2. "*Hilkhot Kiddush Ha-Hodesh al-pi ha-Rambam*": J.J. Ajdler, *Sifriati*, 1996.
3. *Tekhunat ha-Shamayim: Raphael ha-Levi Hannove*r; 1756. Reproduced in Poel ha-Shem, Vol. 2, Bnei Berak 1968; and in Vol. 3, Bnei Berak c. 1999. Reedited in 1997 by R. Eytan Tsikuni of Netivot. See chapter 44 for the sun, and chapters 54-59 for the moon.
4. *Sanctification of the New Moon*, Yale Judaica Series, Vol. XI, 1967, pp. 126-127 and 133-134.
5. *Rabbinical Mathematics and Astronomy*: Feldman, 1931, pp. 106, 114, 132.
6. *A Survey of the Almagest*: O. Pedersen, 1974, pp. 151-151 and 192-193.

א לוח מהלך השמש והירח האמצעי עם המולדות והתיקונים למחזורים

אמצע הראש	אמצע מסלול הירח	גובה השמש	אמצע השמש והירח	תיקונים	מולדות	מחזורים
S o I II	S o I II	S o I II	S o I II			
2. 25. 37. 59	8. 28. 12. 5	0. 11. 36. 36	5. 15. 33. 5	4506 לגרוע	2. 5. 204	עיקר
0. 7. 28. 33	10. 6. 53. 14	0. 0. 17. 21	0. 0. 5. 3	0. 45. 12	2. 16. 595	א
0. 14. 57. 5	8. 13. 46. 28	0. 0. 35. 42	0. 0. 10. 5	0. 90. 24	5. 9. 110	ב
0. 22. 25. 38	6. 20. 39. 42	0. 0. 52. 3	0. 0. 15. 8	0. 135. 36	1. 1. 705	ג
0. 29. 54. 11	4. 27. 32. 56	0. 1. 9. 24	0. 0. 20. 11	0. 180. 48	3. 18. 220	ד
1. 7. 22. 44	3. 4. 26. 9	0. 1. 26. 45	0. 0. 25. 13	0. 226. 0	6. 10. 815	ה
1. 14. 51. 16	1. 11. 19. 23	0. 1. 44. 6	0. 0. 30. 16	0. 271. 12	2. 3. 330	ו
1. 22. 19. 49	11. 18. 12. 37	0. 2. 1. 27	0. 0. 35. 19	0. 316. 24	4. 19. 925	ז
1. 29. 48. 22	9. 25. 5. 51	0. 2. 18. 48	0. 0. 40. 22	0. 361. 36	7. 12. 440	ח
2. 7. 16. 54	8. 1. 59. 5	0. 2. 36. 9	0. 0. 45. 24	0. 406. 48	3. 4. 1035	ט
2. 14. 45. 27	6. 8. 52. 19	0. 2. 53. 30	0. 0. 50. 27	0. 452. 0	5. 21. 550	יוד
4. 29. 30. 54	0. 17. 44. 38	0. 5. 46. 59	0. 1. 40. 54	0. 903. 59	4. 19. 20	כ
7. 14. 16. 21	6. 26. 36. 56	0. 8. 40. 29	0. 2. 31. 21	1. 275. 59	3. 16. 570	ל
9. 29. 1. 48	1. 5. 29. 15	0. 11. 33. 58	0. 3. 21. 48	1. 727. 59	2. 14. 40	מ
0. 13. 47. 15	7. 14. 21. 34	0. 14. 27. 28	0. 4. 12. 14	2. 99. 59	1. 11. 590	נ
2. 28. 32. 42	1. 23. 13. 53	0. 17. 20. 57	0. 5. 2. 41	2. 551. 58	7. 9. 60	ס
5. 13. 18. 9	8. 2. 6. 12	0. 20. 14. 27	0. 5. 53. 8	2. 1003. 58	6. 6. 610	ע
7. 28. 3. 36	2. 10. 58. 30	0. 23. 7. 56	0. 6. 43. 35	3. 375. 58	5. 4. 80	פ
10. 12. 49. 3	8. 19. 50. 49	0. 26. 1. 26	0. 7. 34. 2	3. 827. 57	4. 1. 630	צ
0. 27. 34. 30	2. 28. 43. 8	0. 28. 54. 55	0. 8. 24. 29	4. 199. 57	2. 23. 100	ק
1. 25. 9. 0	5. 27. 26. 16	1. 27. 49. 51	0. 16. 48. 58	8. 399. 54	5. 22. 200	ר
2. 22. 43. 30	8. 26. 9. 24	2. 26. 44. 46	0. 25. 13. 27	12. 599. 52	1. 21. 300	ש
3. 20. 18. 0	11. 24. 52. 32	3. 25. 39. 41	1. 3. 37. 55	16. 799. 49	4. 20. 400	ת
4. 17. 52. 30	2. 23. 35. 41	4. 24. 34. 37	1. 12. 2. 24	20. 999. 46	7. 19. 500	תק

Table 1: Movements of sun and moon during 19-year cycles.

ב מהלך השמש והירח האמצעי עם המולדות והתיקונים לשנים

	מולדות (ימים שעות חלקים)	תיקונים (שעות חלקים)	אמצע השמש והירח (S o I II)	גובה השמש (I II)	אמצע מסלול הירח (S o I II)	אמצע הראש (S o I II)
א	4. 8. 876	2. 18	11. 19. 16. 51	0. 53	10. 9. 47. 55	0. 18. 45. 53
ב	1. 17. 672	4. 37	11. 8. 33. 42	1. 46	8. 19. 35. 49	1. 7. 31. 46
ג	7. 15. 181	7. 7	11. 26. 56. 58	2. 54	7. 25. 12. 43	1. 27. 51. 28
ד	4. 23. 1057	9. 25	11. 16. 13. 49	3. 37	6. 5. 0. 38	2. 16. 37. 21
ה	2. 8. 853	11. 44	11. 5. 30. 40	4. 30	4. 14. 48. 32	3. 5. 23. 14
ו	1. 6. 362	14. 14	11. 23. 53. 56	5. 28	3. 20. 25. 27	3. 25. 42. 57
ז	5. 15. 158	16. 32	11. 13. 10. 47	6. 21	2. 0. 13. 21	4. 14. 28. 50
ח	4. 12. 747	19. 2	0. 1. 34. 2	7. 19	1. 5. 50. 15	5. 4. 48. 32
ט	1. 21. 543	21. 21	11. 20. 50. 54	8. 12	11. 15. 38. 10	5. 23. 34. 25
יוד	6. 6. 339	23. 39	11. 10. 7. 45	9. 5	9. 25. 26. 4	6. 12. 20. 18
יא	5. 3. 928	26. 9	11. 28. 31. 0	10. 2	9. 1. 2. 59	7. 2. 40. 1
יב	2. 12. 724	28. 28	11. 17. 47. 51	10. 56	7. 10. 50. 53	7. 21. 25. 54
יג	6. 21. 520	30. 46	11. 7. 4. 43	11. 49	5. 20. 38. 48	8. 10. 11. 47
יד	5. 19. 29	33. 16	11. 25. 27. 58	12. 46	4. 26. 15. 42	9. 0. 31. 29
טו	3. 3. 905	35. 35	11. 14. 44. 49	13. 39	3. 6. 3. 36	9. 19. 17. 22
טז	7. 12. 701	37. 53	11. 4. 1. 41	14. 33	1. 15. 51. 31	10. 8. 3. 15
יז	6. 10. 210	40. 23	11. 22. 24. 56	15. 30	0. 21. 28. 25	10. 28. 22. 57
יח	3. 19. 6	42. 42	11. 11. 41. 47	16. 23	11. 1. 16. 20	11. 17. 8. 50

ג לוח מהלך השמש והירח האמצעי עם המולדות והתיקונים לחדשים

	מולדות	תיקונים	אמצע השמש והירח	גובה השמש	אמצע מסלול הירח	אמצע הראש
א	1. 12. 793	0. 12	0. 29. 6. 24	0. 4	0. 25. 49. 0	0. 1. 33. 49
ב	3. 1. 506	0. 23	1. 28. 12. 49	0. 9	1. 21. 37. 59	0. 3. 7. 39
ג	4. 14. 219	0. 35	2. 27. 19. 13	0. 13	2. 17. 26. 59	0. 4. 41. 28
ד	6. 2. 1012	0. 46	3. 26. 25. 37	0. 18	3. 13. 15. 58	0. 6. 15. 18
ה	7. 15. 725	0. 58	4. 25. 32. 1	0. 22	4. 9. 4. 58	0. 7. 49. 7
ו	2. 4. 438	1. 9	5. 24. 38. 26	0. 27	5. 4. 53. 57	0. 9. 22. 56
ז	3. 17. 151	1. 21	6. 23. 44. 50	0. 31	6. 0. 42. 57	0. 10. 56. 46
ח	5. 5. 944	1. 32	7. 22. 51. 14	0. 35	6. 26. 31. 56	0. 12. 30. 35
ט	6. 18. 657	1. 44	8. 21. 57. 38	0. 40	7. 22. 20. 56	0. 14. 4. 25
יוד	1. 7. 370	1. 55	9. 21. 4. 3	0. 44	8. 18. 9. 55	0. 15. 38. 14
יא	2. 20. 83	2. 7	10. 20. 10. 27	0. 49	9. 13. 58. 55	0. 17. 12. 4
יב	4. 8. 876	2. 18	11. 19. 16. 51	0. 53	10. 9. 47. 55	0. 18. 45. 53
יג	5. 21. 589	2. 30	0. 18. 23. 15	0. 58	11. 5. 36. 54	0. 20. 19. 42
חצי חודש	0. 18. 396	0. 6	{0. 14. 33. 12 / 6. 14. 33. 12}	0. 2	6. 12. 54. 30	0. 0. 46. 55

ד לוח חילוף חלקי תתרף לדקי שעות

חלקי תתרף	דקי שעות (I II III)
א	0. 3. 20
ב	0. 6. 40
ג	0. 10. 0
ד	0. 13. 20
ה	0. 16. 40
ו	0. 20. 0
ז	0. 23. 20
ח	0. 26. 40
ט	0. 30. 0
יוד	0. 33. 20
כ	1. 6. 40
ל	1. 40. 0
מ	2. 13. 20
נ	2. 46. 40
ס	3. 20. 0
ע	3. 53. 20
פ	4. 26. 40
צ	5. 0. 0
ק	5. 33. 20
ר	11. 6. 40
ש	16. 40. 0
ת	22. 13. 20
תק	27. 46. 40
תר	33. 20. 0
תש	38. 53. 20
תת	44. 26. 40
תתק	50. 0. 0
תתר	55. 33. 20
תקם	30. 0. 0
תתרף	60. 0. 0

Table 2: Movements of sun and moon during years (less than 19 years).

Table 3: Movements of sun and moon during lunar months.

Table 4: Transformation of time expressed in *halakim* into minutes and seconds.

ה לוח מהלך השמש והירח לימים

אמצע הראש	אמצע המסלול	אמצע הירח	גובה השמש	אמצע השמש	לימים
o I II	S o I II	S o I II	II	o I II	
0. 3.11	0.13. 3.54	0.13.10.35	0	0.59. 8	1
0. 6.21	0.26. 7.48	0.26.21.10	0	1.58.17	2
0. 9.32	1. 9.11.42	1. 9.31.45	0	2.57.25	3
0.12.43	1.22.15.36	1.22.42.20	1	3.56.33	4
0.15.53	2. 5.19.30	2. 5.52.55	1	4.55.42	5
0.19. 4	2.18.23.24	2.19. 3.30	1	5.54.50	6
0.22.14	3. 1.27.18	3. 2.14. 5	1	6.53.58	7
0.25.25	3.14.31.11	3.15.24.40	1	7.53. 7	8
0.28.36	3.27.35. 5	3.28.35.15	1	8.52.15	9
0.31.46	4.10.38.59	4.11.45.50	2	9.51.23	10
0.34.57	4.23.42.53	4.24.56.25	2	10.50.32	11
0.38. 8	5. 6.46.47	5. 8. 7. 0	2	11.49.40	12
0.41.18	5.19.50.41	5.21.17.35	2	12.48.48	13
0.44.29	6. 2.54.35	6. 4.28.10	2	13.47.57	14
0.47.39	6.15.58.29	6.17.38.45	2	14.47. 5	15
0.50.50	6.29. 2.23	7. 0.49.20	2	15.46.13	16
0.54. 1	7.12. 6.17	7.13.59.56	3	16.45.22	17
0.57.11	7.25.10.11	7.27.10.31	3	17.44.30	18
1. 0.22	8. 8.14. 5	8.10.21. 6	3	18.43.38	19
1. 3.33	8.21.17.59	8.23.31.41	3	19.42.47	20
1. 6.43	9. 4.21.53	9. 6.42.16	3	20.41.55	21
1. 9.54	9.17.25.46	9.19.52.51	3	21.41. 3	22
1.13. 4	10. 0.29.40	10. 3. 3.26	3	22.40.12	23
1.16.15	10.13.33.34	10.16.14. 1	4	23.39.20	24
1.19.26	10.26.37.28	10.29.24.36	4	24.38.28	25
1.22.36	11. 9.41.22	11.12.35.11	4	25.37.37	26
1.25.47	11.22.45.16	11.25.45.46	4	26.36.45	27
1.28.58	0. 5.49.10	0. 8.56.21	4	27.35.53	28
1.32. 8	0.18.53. 4	0.22. 6.56	4	28.35. 2	29
1.35.19	1. 1.56.58	1. 5.17.31	5	29.34.10	30

ו לוח מהלך השמש והירח לשעות

אמצע הראש	אמצע המסלול	אמצע הירח	אמצע השמש	
III IV	II III IV	II III IV	III IV	שניים
II III	I II III	I II III	II III	דקים
I II	o I II	o I II	I II	שעות
0. 8	0.32.40	0.32.56	2. 28	1
0. 16	1. 5.19	1. 5.53	4. 56	2
0. 24	1.37.59	1.38.49	7. 24	3
0. 32	2.10.39	2.11.46	9. 51	4
0. 40	2.43.19	2.44.42	12. 19	5
0. 48	3.15.58	3.17.39	14. 47	6
0. 56	3.48.38	3.50.35	17. 15	7
1. 4	4.21.18	4.23.32	19. 43	8
1. 11	4.53.58	4.56.28	22. 11	9
1. 19	5.26.37	5.29.25	24. 38	10
1. 27	5.59.17	6. 2.21	27. 6	11
1. 35	6.31.57	6.35.18	29. 34	12
1. 43	7. 4.37	7. 8.14	32. 2	13
1. 51	7.37.16	7.41.10	34. 30	14
1. 59	8. 9.56	8.14. 7	36. 58	15
2. 7	8.42.36	8.47. 3	39. 26	16
2. 15	9.15.16	9.20. 0	41. 53	17
2. 23	9.47.55	9.52.56	44. 21	18
2. 31	10.20.35	10.25.53	46. 49	19
2. 39	10.53.15	10.58.49	49. 17	20
2. 47	11.25.55	11.31.46	51. 45	21
2. 55	11.58.34	12. 4.42	54. 13	22
3. 3	12.31.14	12.37.39	56. 40	23
3. 11	13. 3.54	13.10.35	59. 8	24
3. 19	13.36.34	13.43.31	61. 36	25
3. 27	14. 9.13	14.16.28	64. 4	26
3. 34	14.41.53	14.49.24	66. 32	27
3. 42	15.14.33	15.22.21	69. 0	28
3. 50	15.47.13	15.55.17	71. 28	29
3. 58	16.19.52	16.28.14	73. 55	30

Table 5: Movement of sun and moon for days.

Table 6: Movement of sun and moon for hours.

ח לוח מנת מסלול השמש לפי ערך המסלול

מעלות	0	1	2	3	4	5	
	0 1	0 1	0 1	0 1	0 1	0 1	
0	0. 0	0. 58	1. 41	1. 59	1. 45	1. 1	30
1	0. 2	1. 0	1. 43	1. 59	1. 44	1. 0	29
2	0. 4	1. 1	1. 44	1. 59	1. 43	0. 58	28
3	0. 6	1. 3	1. 44	1. 59	1. 42	0. 56	27
4	0. 8	1. 5	1. 45	1. 59	1. 41	0. 54	26
5	0. 10	1. 6	1. 46	1. 59	1. 39	0. 52	25
6	0. 12	1. 8	1. 47	1. 59	1. 38	0. 50	24
7	0. 14	1. 10	1. 48	1. 59	1. 37	0. 48	23
8	0. 16	1. 11	1. 49	1. 58	1. 36	0. 46	22
9	0. 18	1. 13	1. 50	1. 58	1. 34	0. 44	21
10	0. 20	1. 15	1. 51	1. 58	1. 33	0. 42	20
11	0. 22	1. 16	1. 51	1. 58	1. 32	0. 40	19
12	0. 24	1. 18	1. 52	1. 57	1. 31	0. 38	18
13	0. 26	1. 19	1. 53	1. 57	1. 29	0. 36	17
14	0. 28	1. 21	1. 53	1. 57	1. 28	0. 34	16
15	0. 30	1. 22	1. 54	1. 56	1. 26	0. 32	15
16	0. 32	1. 24	1. 55	1. 56	1. 25	0. 30	14
17	0. 34	1. 25	1. 55	1. 55	1. 23	0. 28	13
18	0. 36	1. 26	1. 56	1. 54	1. 22	0. 26	12
19	0. 38	1. 28	1. 56	1. 54	1. 20	0. 23	11
20	0. 40	1. 29	1. 57	1. 53	1. 19	0. 21	10
21	0. 41	1. 31	1. 57	1. 53	1. 17	0. 19	9
22	0. 43	1. 32	1. 57	1. 52	1. 15	0. 17	8
23	0. 45	1. 33	1. 58	1. 51	1. 14	0. 15	7
24	0. 47	1. 34	1. 58	1. 50	1. 12	0. 13	6
25	0. 49	1. 36	1. 58	1. 49	1. 10	0. 11	5
26	0. 51	1. 37	1. 59	1. 49	1. 9	0. 8	4
27	0. 53	1. 38	1. 59	1. 48	1. 7	0. 6	3
28	0. 54	1. 39	1. 59	1. 47	1. 5	0. 4	2
29	0. 56	1. 40	1. 59	1. 46	1. 3	0. 2	1
30	0. 58	1. 41	1. 59	1. 45	1. 1	0. 0	0
	11	10	9	8	7	6	מעלות

ז לוח מהלך השמש והירח לדקי שעות

אמצע הראש	אמצע המסלול		אמצע הירח		אמצע השמש		
IV	III	IV	III	IV	III	IV	שלישיים
III	II	III	II	III	II	III	שניים
II	I	II	I	II	I	II	דקים
4	16.	53	17.	1	1.	16	31
4	17.	25	17.	34	1.	19	32
4	17.	58	18.	7	1.	21	33
5	18.	31	18.	40	1.	24	34
5	19.	3	19.	13	1.	26	35
5	19.	36	19.	46	1.	29	36
5	20.	9	20.	19	1.	31	37
5	20.	41	20.	52	1.	34	38
5	21.	14	21.	25	1.	36	39
5	21.	46	21.	58	1.	39	40
5	22.	19	22.	31	1.	41	41
6	22.	52	23.	4	1.	43	42
6	23.	24	23.	36	1.	46	43
6	23.	57	24.	9	1.	48	44
6	24.	30	24.	42	1.	51	45
6	25.	2	25.	15	1.	53	46
6	25.	35	25.	48	1.	56	47
6	26.	8	26.	21	1.	58	48
6	26.	40	26.	54	2.	1	49
7	27.	13	27.	27	2.	3	50
7	27.	46	28.	0	2.	6	51
7	28.	18	28.	33	2.	8	52
7	28.	51	29.	6	2.	11	53
7	29.	24	29.	39	2.	13	54
7	29.	56	30.	12	2.	16	55
7	30.	29	30.	45	2.	18	56
8	31.	2	31.	18	2.	20	57
8	31.	34	31.	51	2.	23	58
8	32.	7	32.	24	2.	25	59
8	32.	40	32.	56	2.	28	60

Table 7: Movement of sun and moon for minutes.

Table 8: The quota of the anomaly of the sun.

יוד לוח רוחב הירח לפי ערך מסלול הרוחב

	צפ. 0. דר. 6.	צפ. 1. דר. 7.	צפ. 2. דר. 8.	
	o I	o I	o I	
0	0. 0	2. 30	4. 20	30
1	0. 5	2. 34	4. 22	29
2	0. 10	2. 39	4. 25	28
3	0. 16	2. 43	4. 27	27
4	0. 21	2. 48	4. 30	26
5	0. 26	2. 52	4. 32	25
6	0. 31	2. 56	4. 34	24
7	0. 37	3. 0	4. 36	23
8	0. 42	3. 5	4. 38	22
9	0. 47	3. 9	4. 40	21
10	0. 52	3. 13	4. 42	20
11	0. 57	3. 17	4. 44	19
12	1. 2	3. 21	4. 45	18
13	1. 7	3. 24	4. 47	17
14	1. 12	3. 28	4. 48	16
15	1. 18	3. 32	4. 50	15
16	1. 23	3. 36	4. 51	14
17	1. 28	3. 39	4. 52	13
18	1. 33	3. 43	4. 53	12
19	1. 38	3. 46	4. 54	11
20	1. 43	3. 50	4. 55	10
21	1. 47	3. 53	4. 56	9
22	1. 52	3. 56	4. 57	8
23	1. 57	4. 0	4. 58	7
24	2. 2	4. 3	4. 58	6
25	2. 7	4. 6	4. 59	5
26	2. 11	4. 9	4. 59	4
27	2. 16	4. 12	5. 0	3
28	2. 21	4. 14	5. 0	2
29	2. 25	4. 17	5. 0	1
30	2. 30	4. 20	5. 0	0
	צפ. 5. דר. 11	צפ. 4 דר. 10	צפ. 3. דר. 9.	

ט לוח מנת מרחק הכפול וחלק היחוס לירח לפי ערך מרחק הכפול

להוסיף	0 מנת	0 חלק היחוס	1 מנת	1 חלק היחוס	2 מנת	2 חלק היחוס	3 מנת	3 חלק היחוס	4 מנת	4 חלק היחוס	5 מנת	5 חלק היחוס	לגרוע
	o I	I	o I	I	o I	I	o I	I	o I	I	o I	I	
0	0. 0	0	4. 23	3	8. 35	12	12. 0	26	13. 2	43	9. 17	55	30
1	0. 9	0	4. 32	3	8. 43	13	12. 5	27	13. 0	43	9. 3	56	29
2	0. 17	0	4. 41	3	8. 51	13	12. 9	27	12. 59	44	8. 49	56	28
3	0. 26	0	4. 49	4	8. 59	14	12. 14	28	12. 56	44	8. 35	56	27
4	0. 35	0	4. 58	4	9. 6	14	12. 19	28	12. 53	45	8. 20	56	26
5	0. 44	0	5. 6	4	9. 14	15	12. 23	29	12. 49	45	8. 4	57	25
6	0. 52	0	5. 15	4	9. 22	15	12. 28	30	12. 46	45	7. 47	57	24
7	1. 1	0	5. 23	5	9. 29	15	12. 31	30	12. 42	46	7. 30	57	23
8	1. 10	0	5. 32	5	9. 37	16	12. 35	31	12. 38	46	7. 14	57	22
9	1. 19	0	5. 40	5	9. 44	16	12. 39	31	12. 33	47	6. 58	58	21
10	1. 28	0	5. 49	5	9. 52	17	12. 43	32	12. 28	47	6. 41	58	20
11	1. 37	0	5. 58	6	9. 59	17	12. 46	32	12. 22	47	6. 23	58	19
12	1. 45	1	6. 7	6	10. 6	18	12. 49	33	12. 15	48	6. 4	58	18
13	1. 54	1	6. 15	6	10. 14	18	12. 52	33	12. 9	48	5. 46	58	17
14	2. 3	1	6. 23	7	10. 21	19	12. 54	34	12. 3	49	5. 27	59	16
15	2. 12	1	6. 32	7	10. 28	19	12. 57	35	11. 56	49	5. 8	59	15
16	2. 20	1	6. 42	7	10. 34	20	12. 59	35	11. 48	50	4. 49	59	14
17	2. 29	1	6. 49	8	10. 41	20	13. 1	36	11. 40	50	4. 29	59	13
18	2. 38	1	6. 57	8	10. 48	21	13. 3	36	11. 31	51	4. 9	59	12
19	2. 47	1	7. 5	8	10. 54	21	13. 4	37	11. 22	51	3. 50	59	11
20	2. 56	2	7. 14	9	11. 1	22	13. 6	37	11. 13	52	3. 30	59	10
21	3. 5	2	7. 22	9	11. 7	22	13. 7	38	11. 3	52	3. 9	60	9
22	3. 14	2	7. 31	9	11. 13	22	13. 8	38	10. 53	53	2. 49	60	8
23	3. 22	2	7. 39	10	11. 19	23	13. 8	39	10. 43	53	2. 28	60	7
24	3. 31	2	7. 47	10	11. 25	23	13. 8	39	10. 32	53	2. 6	60	6
25	3. 40	2	7. 55	10	11. 32	24	13. 8	40	10. 21	54	1. 46	60	5
26	3. 48	2	8. 3	11	11. 38	24	13. 8	40	10. 9	54	1. 25	60	4
27	3. 57	3	8. 11	11	11. 43	25	13. 7	41	9. 56	54	1. 3	60	3
28	4. 5	3	8. 19	11	11. 48	25	13. 6	41	9. 44	55	0. 42	60	2
29	4. 14	3	8. 27	12	11. 54	26	13. 4	42	9. 31	55	0. 21	60	1
30	4. 23	3	8. 35	12	12. 0	26	13. 2	43	9. 17	55	0. 0	60	0
	11		10		9		8		7		6		

Table 9: Quota of the double elongation and the proportion c in function of the double elongation.

Table 10: The moon's latitude in function of the argument of latitude.

יא לוח מנת מסלול הנכון ושינוי אלכסון לירח לפי ערך מסלול הנכון

מעלות	0		1		2		3		4		5		
	מנת המסלול	שינוי אלכסון	מנת המסלול	שינוי אלכסון	מנת המסלול	שינוי אלכסון	מנת המסלול	שינוי אלכסון	מנת המסלול	שינוי אלכסון	מנת המסלול	שינוי אלכסון	
	o I	o I	o I	o I	o I	o I	o I	o I	o I	o I	o I	o I	
0	0. 0	0. 0	2. 20	1. 5	4. 9	2. 2	4. 59	2. 36	4. 31	2. 33	2. 42	1. 37	30
1	0. 5	0. 2	2. 24	1. 8	4. 12	2. 3	5. 0	2. 36	4. 29	2. 32	2. 37	1. 34	29
2	0. 10	0. 4	2. 28	1. 10	4. 15	2. 5	5. 0	2. 37	4. 27	2. 30	2. 33	1. 31	28
3	0. 15	0. 6	2. 32	1. 12	4. 18	2. 6	5. 0	2. 38	4. 25	2. 28	2. 28	1. 28	27
4	0. 19	0. 9	2. 37	1. 14	4. 20	2. 8	5. 0	2. 38	4. 22	2. 27	2. 23	1. 25	26
5	0. 24	0. 11	2. 41	1. 16	4. 23	2. 9	5. 0	2. 39	4. 19	2. 26	2. 18	1. 22	25
6	0. 29	0. 13	2. 45	1. 18	4. 25	2. 11	5. 0	2. 39	4. 16	2. 25	2. 13	1. 19	24
7	0. 34	0. 15	2. 49	1. 20	4. 27	2. 13	5. 0	2. 39	4. 13	2. 24	2. 8	1. 16	23
8	0. 39	0. 17	2. 53	1. 22	4. 30	2. 14	5. 0	2. 39	4. 10	2. 22	2. 3	1. 13	22
9	0. 44	0. 19	2. 57	1. 24	4. 32	2. 15	5. 0	2. 39	4. 7	2. 21	1. 57	1. 11	21
10	0. 49	0. 22	3. 1	1. 26	4. 33	2. 17	4. 59	2. 40	4. 3	2. 20	1. 52	1. 7	20
11	0. 53	0. 24	3. 5	1. 28	4. 36	2. 18	4. 59	2. 40	4. 0	2. 18	1. 47	1. 4	19
12	0. 58	0. 26	3. 9	1. 30	4. 38	2. 19	4. 59	2. 40	3. 57	2. 16	1. 41	1. 1	18
13	1. 2	0. 29	3. 13	1. 31	4. 40	2. 20	4. 58	2. 40	3. 54	2. 14	1. 36	0. 58	17
14	1. 7	0. 31	3. 17	1. 33	4. 42	2. 21	4. 58	2. 39	3. 50	2. 12	1. 31	0. 54	16
15	1. 12	0. 33	3. 21	1. 35	4. 44	2. 22	4. 57	2. 39	3. 47	2. 10	1. 25	0. 51	15
16	1. 17	0. 35	3. 24	1. 37	4. 45	2. 24	4. 56	2. 39	3. 43	2. 8	1. 20	0. 47	14
17	1. 21	0. 38	3. 27	1. 39	4. 47	2. 25	4. 55	2. 39	3. 39	2. 6	1. 14	0. 45	13
18	1. 26	0. 40	3. 31	1. 41	4. 49	2. 26	4. 54	2. 39	3. 35	2. 5	1. 8	0. 42	12
19	1. 31	0. 42	3. 35	1. 43	4. 50	2. 27	4. 52	2. 39	3. 31	2. 3	1. 3	0. 38	11
20	1. 35	0. 44	3. 38	1. 45	4. 51	2. 28	4. 50	2. 38	3. 26	2. 2	0. 57	0. 35	10
21	1. 40	0. 46	3. 41	1. 47	4. 53	2. 29	4. 49	2. 38	3. 22	1. 59	0. 52	0. 31	9
22	1. 44	0. 49	3. 45	1. 48	4. 54	2. 30	4. 48	2. 37	3. 18	1. 57	0. 45	0. 29	8
23	1. 49	0. 51	3. 48	1. 50	4. 55	2. 31	4. 46	2. 37	3. 14	1. 54	0. 40	0. 25	7
24	1. 53	0. 53	3. 51	1. 52	4. 56	2. 32	4. 45	2. 36	3. 10	1. 52	0. 34	0. 21	6
25	1. 58	0. 55	3. 54	1. 54	4. 57	2. 32	4. 43	2. 35	3. 6	1. 49	0. 29	0. 17	5
26	2. 2	0. 57	3. 58	1. 55	4. 58	2. 33	4. 41	2. 35	3. 1	1. 47	0. 23	0. 14	4
27	2. 7	0. 59	4. 1	1. 56	4. 59	2. 33	4. 39	2. 34	2. 57	1. 44	0. 17	0. 11	3
28	2. 11	1. 1	4. 4	1. 58	4. 59	2. 34	4. 37	2. 33	2. 52	1. 42	0. 12	0. 7	2
29	2. 16	1. 3	4. 6	2. 0	4. 59	2. 35	4. 34	2. 33	2. 47	1. 39	0. 6	0. 3	1
30	2. 20	1. 5	4. 9	2. 2	4. 59	2. 36	4. 31	2. 33	2. 42	1. 37	0. 0	0. 0	0
	11		10		9		8		7		6		מעלות

Table 11: q the quota of the true anomaly and angle s in function of the true anomaly.

יג לוח גליזת הנטייה מהכוכבים שיש להם רוחב לפי ערך מקום הכוכב ורחבו

		1	2	3	4	5	6	7	8	9		
		1	1	1	1	1	1	1	1	1		
	0	5	10	15	20	25	30	35	40	46	30	
	3	5	10	15	20	25	30	35	40	46	27	
טלה מאזנים	6	5	10	15	20	25	30	35	40	45	24	דגים בתולה
	9	5	10	15	20	25	29	34	39	45	21	
	12	5	10	15	19	24	29	34	39	45	18	
	15	5	10	14	19	24	28	33	38	44	15	
	18	5	9	14	18	23	27	32	37	43	12	
	21	4	9	14	18	22	26	31	36	41	9	
	24	4	8	13	17	21	25	30	35	40	6	
	27	4	8	13	17	20	24	29	34	38	3	
0.	30	4	8	12	16	19	23	28	32	36	30.	0
שור עקרב	3	4	8	11	15	18	22	26	30	34	27	דלי אריה
	6	4	7	10	14	17	21	24	28	32	24	
	9	3	6	9	13	16	20	23	27	30	21	
	12	3	6	9	12	15	18	21	25	28	18	
	15	3	6	8	11	14	17	20	23	26	15	
	18	3	5	7	10	13	16	18	21	23	12	
	21	3	5	6	9	12	14	16	18	20	9	
	24	2	4	6	8	10	12	14	16	18	6	
	27	2	4	5	7	9	11	12	14	16	3	
0.	30	2	3	4	6	7	9	11	12	14	30.	0
	3	2	2	3	5	6	8	10	10	11	27	
	6	2	2	3	4	5	6	8	8	9	24	
תאומים קשת	9	1	2	2	3	4	5	6	6	7	21	גדי סרטן
	12	1	1	2	2	3	4	4	5	5	18	
	15	1	1	1	1	2	3	3	3	3	15	
	18	1	1	1	1	1	2	2	2	2	12	
	21	0	0	0	0	0	1	1	1	1	9	
	24	0	0	0	0	0	0	1	1	1	6	
	27	0	0	0	0	0	0	0	0	0	3	
	30	0	0	0	0	0	0	0	0	0	0	

החלקים מלוח זו תגרע לעולם מן הרוחב, והנשאר תחבר אל נטיית מקום הכוכב אם הנטייה והרוחב הם מצד אחד, או תגרע הפחות מן היתר אם הם משני צדדים, ולצד שהיה היתר לאותו צד יהיה הנטייה.

יב לוח נטיית מקום השמש והירח לפי ערך מקום האמתי

	טלה עם מאזנים דר		שור עם עקרב דר		תאומים עם קשת דר		
	0	1	0	1	0	1	
0	0.	0	11.	30	20.	12	30
1	0.	24	11.	51	20.	25	29
2	0.	48	12.	12	20.	37	28
3	1.	12	12.	33	20.	49	27
4	1.	36	12.	53	21.	0	26
5	2.	0	13.	13	21.	11	25
6	2.	23	13.	33	21.	22	24
7	2.	47	13.	53	21.	32	23
8	3.	11	14.	13	21.	42	22
9	3.	35	14.	32	21.	51	21
10	3.	58	14.	51	22.	0	20
11	4.	22	15.	10	22.	9	19
12	4.	45	15.	28	22.	17	18
13	5.	9	15.	47	22.	25	17
14	5.	32	16.	5	22.	32	16
15	5.	55	16.	23	22.	39	15
16	6.	19	16.	40	22.	46	14
17	6.	42	16.	57	22.	52	13
18	7.	5	17.	14	22.	57	12
19	7.	28	17.	31	23.	3	11
20	7.	50	17.	47	23.	7	10
21	8.	13	18.	3	23.	12	9
22	8.	35	18.	19	23.	15	8
23	8.	58	18.	34	23.	19	7
24	9.	20	18.	49	23.	22	6
25	9.	42	19.	4	23.	24	5
26	10.	4	19.	18	23.	26	4
27	10.	26	19.	32	23.	28	3
28	10.	47	19.	46	23.	29	2
29	11.	9	19.	59	23.	30	1
30	11.	30	20.	12	23.	30	0
	בתולה עם דגים דר		אריה עם דלי דר		סרטן עם גדי דר		

Table 12: Declination of the sun in function of its longitude.
Table 13: Deviation of the declination of the stars that have a latitude in function of their longitude and latitude.

יד לוח עלייה הישרה ונקרא מצעדי המזלות

	טלה	שור	תאומים	סרטן	אריה	בתולה	מאזנים	עקרב	קשת	גדי	דלי	דגים	
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
0	0. 0	27.54	57.48	90. 0	122.12	152. 6	180. 0	207.54	237.48	270. 0	302.12	332. 6	0
1	0. 55	28.51	58.51	91. 5	123.14	153. 3	180.55	208.51	238.51	271. 5	303.14	333. 3	1
2	1. 50	29.49	59.54	92.11	124.16	154. 0	181.50	209.49	239.54	272.11	304.16	334 0	2
3	2. 45	30.47	60.57	93.16	125.18	154.57	182.45	210.47	240.57	273.16	305.18	334.57	3
4	3. 40	31.44	62. 0	94.22	126.20	155.54	183.40	211.44	242. 0	274.22	306.20	335.54	4
5	4. 35	32.42	63. 3	95.27	127.22	156.51	184.35	212.42	243. 3	275.27	307.22	336.51	5
6	5. 30	33.40	64. 6	96.32	128.23	157.47	185.30	213.40	244. 6	276.32	308.23	337.47	6
7	6. 25	34.39	65.10	97.38	129.25	158 44	186.25	214.39	245.10	277.38	309.25	338.44	7
8	7. 21	35.37	66.13	98.43	130.26	159.40	187.21	215.37	246.13	278.43	310.26	339.40	8
9	8. 16	36.36	67.17	99.48	131.27	160.36	188.16	216.36	247.17	279.48	311.27	340.36	9
10	9. 11	37.35	68.21	100.53	132.27	161.33	189.11	217.35	248 21	280.53	312.27	341.33	10
11	10. 6	38.34	69.25	101.58	133.28	162.29	190. 6	218.34	249.25	281.58	313.28	342.29	11
12	11. 2	39.33	70.29	103. 3	134.29	163.24	191. 2	219.33	250.29	283. 3	314.29	343.24	12
13	11.57	40.32	71.34	104. 8	135.29	164 20	191.57	220 32	251.34	284. 8	315.29	344.20	13
14	12.53	41.32	72.38	105.13	136.29	165.16	192.53	221.32	252.38	285.13	316.29	345.16	14
15	13.48	42.31	73.43	106.17	137.29	166.12	193.48	222.31	253.43	286.17	317.29	346.12	15
16	14.44	43.31	74.47	107.22	138.28	167. 7	194.44	223.31	254.47	287.22	318.28	347. 7	16
17	15.40	44.31	75.52	108.26	139.28	168. 3	195.40	224.31	255.52	288.26	319.28	348. 3	17
18	16.36	45.32	76.57	109 31	140.27	168.58	196.36	225 32	256.57	289.31	320.27	348.58	18
19	17.31	46.32	78. 2	110.35	141 26	169.54	197.31	226.32	258. 2	290.35	321.26	349.54	19
20	18.27	47.33	79. 7	111.39	142.25	170.49	198.27	227.33	259. 7	291.39	322.25	350.49	20
21	19.24	48.33	80.12	112.43	143.24	171.44	199.24	228.33	260.12	292.43	323.24	351.44	21
22	20.20	49.34	81.17	113.47	144 23	172.39	200.20	229.34	261.17	293.47	324.23	352.39	22
23	21.16	50.35	82.22	114.50	145 21	173.35	201.16	230.35	262.22	294.50	325.21	353.35	23
24	22.13	51.37	83.28	115.54	146.20	174.30	202.13	231.37	263.28	295.54	326.20	354.30	24
25	23. 9	52.38	84.33	116.57	147.18	175.25	203. 9	232.38	264.33	296.57	327.18	355.25	25
26	24. 6	53.40	85.38	118. 0	148.16	176.20	204. 6	233.40	265.38	298. 0	328.16	356.20	26
27	25. 3	54.42	86.44	119. 3	149.14	177.15	205. 3	234.42	266.44	299. 3	329.14	357.15	27
28	26. 0	55.44	87.49	120. 6	150.11	178.10	206. 0	235.44	267.49	300. 6	330.11	358.10	28
29	26.57	56.46	88.55	121. 9	151. 9	179. 5	206.57	236.46	268.55	301. 9	331. 9	359. 5	29
30	27.54	57.48	90. 0	122.12	152. 6	180. 0	207.54	237.48	270. 0	302.12	332. 6	360. 0	30

Table 14: Right ascension of the points of the ecliptic.

ט״ו לוח הבדל השקיעה לאיזה מקומות המפורסמים לפי ערך הנטייה

מעלות הנטייה	רוחב	ירושלים	רוחב	קונשטאנטינאפל	ראמא	פלארענץ	ווענעדיג	ווינא	מעטץ	פרנקפורט פראג	לונדן	אמשטרדם	הנובר ברלין	האמבורג	קאפן האגן	מעלות הנטייה
	o I 29. 0	o I 32. 0	o I 35. 0	o I 41. 0	o I 41.50	o I 43.41	o I 45.33	o I 48.22	o I 49.14	o I 50. 4	o I 51.29	o I 52.21	o I 52.30	o I 53.41	o o 55.41	
	o I	o I	o I	o I	o I	o I	o I	o I	o I	o I	o I	o I	o I	o I	o I	
1	0.33	0.37	0.42	0.52	0.54	0.57	1. 1	1. 8	1.10	1.12	1.15	1.18	1.19	1.22	1.28	1
2	1. 7	1.15	1.24	1.44	1.47	1.55	2. 2	2.15	2.19	2.23	2.31	2.36	2.37	2.43	2.56	2
3	1.40	1.53	2. 6	2.37	2.41	2.52	3. 4	3.23	3.29	3.35	3.47	3.54	3.55	4. 5	4.24	3
4	2.14	2.31	2.48	3.29	3.35	3.50	4. 5	4.31	4.39	4.47	5. 3	5.12	5.14	5.28	5.53	4
5	2.47	3. 8	3.31	4.22	4.30	4.48	5. 7	5.39	5.49	6. 0	6.19	6.31	6.33	6.50	7.22	5
6	3.20	3.46	4.13	5.14	5.24	5.46	6. 9	6.47	7. 0	7.13	7.35	7.50	7.52	8.13	8.51	6
7	3.54	4.24	4.56	6. 8	6.19	6.44	7.11	7.56	8.11	8.26	8.53	9.10	9.12	9.37	10.22	7
8	4.28	5. 2	5.39	7. 1	7.13	7.43	8.14	9. 6	9.23	9.40	10.10	10.30	10.33	11. 1	11.53	8
9	5. 2	5.41	6.22	7.55	8. 9	8.42	9.17	10.16	10.35	10.54	11.29	11.51	11.55	12.27	13.25	9
10	5.37	6.20	7. 6	8.49	9. 5	9.42	10.21	11.26	11.48	12.10	12.48	13.13	13.17	13.53	14.58	10
11	6.11	6.59	7.49	9.44	10. 1	10.42	11.26	12.38	13. 2	13.26	14. 8	14.36	14.40	15.20	16.32	11
12	6.46	7.38	8.34	10.39	10.58	11.43	12.31	13.50	14.16	14.43	15.30	16. 0	16. 5	16.49	18. 8	12
13	7.21	8.18	9.18	11.35	11.56	12.44	13.37	15. 3	15.32	16. 1	16.52	17.25	17.31	18.18	19.46	13
14	7.57	8.58	10. 3	12.31	12.54	13.47	14.43	16.17	16.49	17.20	18.16	18.52	18.58	19.50	21.25	14
15	8.33	9.38	10.49	13.28	13.52	14.50	15.51	17.33	18. 6	18.40	19.41	20.19	20.26	21.23	23. 6	15
16	9. 9	10.19	11.35	14.26	14.52	15.54	17. 0	18.49	19.26	20. 2	21. 7	21.50	21.57	22.58	24.50	16
17	9.46	11. 0	12.22	15.25	15.53	16.59	18.10	20. 7	20.46	21.25	22.36	23.21	23.29	24.35	26.36	17
18	10.23	11.43	13. 9	16.24	16.55	18. 5	19.20	21.26	22. 8	22.50	24. 6	24.55	25. 3	26.14	28.25	18
19	11. 0	12.25	13.57	17.25	17.57	19.12	20.34	22.47	23.32	24.17	25.38	26.31	26.40	27.56	30.17	19
20	11.38	13. 9	14.46	18.27	19. 1	20.21	21.47	24.10	24.58	25.46	27.13	28. 9	28.19	29.41	32.13	20
21	12.17	13.53	15.36	19.30	20. 6	21.30	23. 2	25.35	26.26	27.18	28.5[illegible]	29.51	30. 1	31.29	34.13	21
22	12.57	14.37	16.26	20.34	21.12	22.42	24.19	27. 2	27.57	28.51	30.31	31.35	31.46	33.21	36.17	22
23	13.37	15.23	17.17	21.39	22.20	23.55	25.38	28.31	29.30	30.28	32.14	33.23	33.35	35.16	38.27	23
24	14.18	16. 9	18.10	22.46	23.29	25.10	27. 0	30. 3	31. 6	32. 8	34. 1	35.16	35.28	37.17	40.42	24
25	14.59	16.56	19. 3	23.55	24.40	26.27	28.23	31.38	32.44	33.51	35.53	37.12	37.25	39.23	43. 5	25
26	15.41	17.45	19.58	25. 5	25.53	27.46	29.49	33.17	34.27	35.38	37.48	39.13	39.28	41.34	45.36	26
27	16.24	18.34	20.54	26.17	27. 8	29. 7	31.18	34.58	36.14	37.30	39.49	41.21	41.36	43.53	48.17	27
28	17. 9	19.24	21.52	27.32	28.25	30.31	32.49	36.44	38. 4	39.26	41.56	43.35	43.52	46.20	51. 9	28
29	17.54	20.16	22.51	28.49	29.45	31.58	24.24	38.35	40. 1	41.28	44.10	45.57	46.15	48.57	54.17	29
30	18.40	21. 9	23.51	30. 7	31. 7	33.28	36. 3	40.30	42. 2	43.36	46.31	48.28	48.48	51.46	57.45	30
31	19.27	22. 3	24.53	31.29	32.32	35. 1	37.46	42.32	44.11	45.52	49. 2	51.10	52.32	54.50	61.40	31
32	20.16	22.59	25.57	32.54	34. 1	36.38	39.34	44.40	46.27	48.17	51.45	54. 6	54.31	58.13	66.15	32
23½	13.57	15.46	17.44	22.13	22.54	24.32	26.19	29.17	30.17	31.18	33. 7	34.18	34.31	36.16	39.34	23½

Table 15: Set lag for different places in function of the sun's declination.

יו לוח חילוף מעלות המשוה לחלקי הזמן

II	III	IV	II
I	II	II	I
שעות	I	II	o
0	4	0	1
0	8	0	2
0	12	0	3
0	16	0	4
0	20	0	5
0	24	0	6
0	28	0	7
0	32	0	8
0	36	0	9
0	40	0	10
1	0	0	15
1	20	0	20
1	40	0	25
2	0	0	30
2	20	0	35
2	40	0	40
3	0	0	45
3	20	0	50
3	40	0	55
4	0	0	60
4	20	0	65
4	40	0	70
5	0	0	75
5	20	0	80
5	40	0	85
6	0	0	90
6	20	0	95
6	40	0	100
13	20	0	200
20	0	0	300

יז לוח נליזת עלייה הישרה מהכוכבים שיש להם רוחב, חלק ראשון

להוסיף { סרטן אריה בתולה צפונית / גדי דלי דגים דרומית || לגרוע { טלה שור תאומים צפונית / מאזנים עקרב קשת דרומית

		1	2	3	4	5	6	7	8	9		
		o I	o I	o I	o I	o I	o I	o I	o I	o I		
טלה מאזנים	0	0. 23	0. 47	1. 11	1. 35	1. 59	2. 23	2. 48	3. 12	3. 37	30	סרטן גדי
	3	0. 23	0. 47	1. 11	1. 35	1. 59	2. 23	2. 48	3. 12	3. 37	27	
	6	0. 23	0. 47	1. 11	1. 35	1. 59	2. 23	2. 48	3. 12	3. 36	24	
	9	0. 23	0. 47	1. 10	1. 34	1. 58	2. 22	2. 47	3. 11	3. 36	21	
	12	0. 23	0. 47	1. 10	1. 34	1. 58	2. 22	2. 47	3. 11	3. 35	18	
	15	0. 23	0. 47	1. 10	1. 34	1. 57	2. 21	2. 46	3. 10	3. 34	15	
	18	0. 23	0. 46	1. 9	1. 32	1. 55	2. 20	2. 44	3. 8	3. 32	12	
	21	0. 23	0. 46	1. 9	1. 31	1. 53	2. 18	2. 42	3. 6	3. 30	9	
	24	0. 22	0. 45	1. 8	1. 30	1. 51	2. 16	2. 40	3. 4	3. 28	6	
	27	0. 22	0. 44	1. 6	1. 28	1. 50	2. 14	2. 37	3. 1	3. 25	3	
0.	30	0. 21	0. 43	1. 5	1. 27	1. 49	2. 12	2. 35	2. 58	3. 22	30.	0
שור עקרב	3	0. 21	0. 42	1. 3	1. 25	1. 47	2. 9	2. 31	2. 55	3. 18	27	אריה דלי
	6	0. 20	0. 41	1. 2	1. 23	1. 44	2. 6	2. 28	2. 50	3. 13	24	
	9	0. 20	0. 40	1. 1	1. 21	1. 42	2. 3	2. 24	2. 46	3. 9	21	
	12	0. 19	0. 39	0. 58	1. 18	1. 38	1. 59	2. 19	2. 41	3. 3	18	
	15	0. 18	0. 37	0. 55	1. 14	1. 33	1. 54	2. 13	2. 34	2. 55	15	
	18	0. 17	0. 35	0. 53	1. 10	1. 30	1. 49	2. 8	2. 28	2. 48	12	
	21	0. 17	0. 33	0. 51	1. 7	1. 26	1. 44	2. 2	2. 20	2. 39	9	
	24	0. 16	0. 31	0. 48	1. 4	1. 21	1. 38	1. 55	2. 12	2. 29	6	
	27	0. 15	0. 30	0. 45	1. 0	1. 16	1. 32	1. 48	2. 4	2. 20	3	
0.	30	0. 14	0. 28	0. 41	0. 55	1. 10	1. 25	1. 40	1. 55	2. 10	30.	0
תאומים קשת	3	0. 13	0. 26	0. 38	0. 51	1. 5	1. 18	1. 31	1. 45	1. 59	27	בתולה דגים
	6	0. 11	0. 23	0. 34	0. 46	0. 58	1. 10	1. 22	1. 35	1. 48	24	
	9	0. 10	0. 20	0. 30	0. 41	0. 52	1. 3	1. 14	1. 24	1. 36	21	
	12	0. 8	0. 17	0. 26	0. 35	0. 44	0. 54	1. 3	1. 13	1. 24	18	
	15	0. 7	0. 14	0. 22	0. 30	0. 38	0. 46	0. 54	1. 2	1. 11	15	
	18	0. 6	0. 11	0. 18	0. 24	0. 30	0. 36	0. 43	0. 51	0. 58	12	
	21	0. 4	0. 8	0. 13	0. 18	0. 23	0. 28	0. 33	0. 39	0. 44	9	
	24	0. 3	0. 6	0. 9	0. 12	0. 15	0. 19	0. 23	0. 27	0. 31	6	
	27	0. 1	0. 2	0. 4	0. 5	0. 7	0. 9	0. 11	0. 13	0. 16	3	
	30	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0	

Table 16: Expression of arcs of the ecliptic in time.

Table 17: Deviation of the right ascension of stars that have a latitude.

לז לוח גליות עלייה הישרה מהכוכבים שיש להם רוחב, חלק שני

לגרוע	סרטן אריה בתולה דרומית / גדי דלי דגים צפונית	להוסיף	טלה שור תאומים דרומית / מאזנים עקרב קשת צפונית

		1	2	3	4	5	6	7	8	9		
		° '	° '	° '	° '	° '	° '	° '	° '	° '		
טלה מאזנים	0	0.24	0.48	1.12	1.35	1.59	2.23	2.47	3.11	3.36	30	דגים בתולה
	3	0.23	0.47	1.11	1.35	1.59	2.23	2.47	3.11	3.35	27	
	6	0.23	0.47	1.11	1.35	1.59	2.23	2.47	3.11	3.34	24	
	9	0.23	0.47	1.11	1.34	1.58	2.22	2.46	3.9	3.32	21	
	12	0.23	0.47	1.11	1.34	1.58	2.21	2.45	3.7	3.30	18	
	15	0.23	0.47	1.10	1.33	1.57	2.20	2.43	3.6	3.28	15	
	18	0.23	0.46	1.9	1.32	1.55	2.18	2.41	3.4	3.26	12	
	21	0.22	0.45	1.9	1.31	1.53	2.16	2.39	3.1	3.23	9	
	24	0.22	0.45	1.8	1.30	1.52	2.14	2.36	2.58	3.20	6	
	27	0.22	0.44	1.6	1.28	1.50	2.12	2.33	2.54	3.15	3	
0	30	0.22	0.43	1.4	1.26	1.47	2.8	2.28	2.48	3.10	30	0
שור עקרב	3	0.21	0.42	1.3	1.24	1.44	2.5	2.25	2.45	3.5	27	דלי אריה
	6	0.20	0.41	1.2	1.22	1.42	2.2	2.21	2.40	2.59	24	
	9	0.19	0.39	0.59	1.19	1.38	1.57	2.15	2.34	2.54	21	
	12	0.19	0.38	0.57	1.16	1.34	1.52	2.10	2.28	2.45	18	
	15	0.19	0.37	0.55	1.13	1.31	1.49	2.6	2.23	2.39	15	
	18	0.18	0.35	0.52	1.10	1.27	1.44	2.0	2.16	2.31	12	
	21	0.17	0.33	0.49	1.6	1.21	1.38	1.54	2.8	2.22	9	
	24	0.16	0.32	0.46	1.2	1.17	1.32	1.47	2.0	2.13	6	
	27	0.15	0.30	0.44	0.58	1.12	1.26	1.39	1.52	2.4	3	
0	30	0.14	0.28	0.41	0.54	1.7	1.20	1.32	1.44	1.55	30	0
תאומים קשת	3	0.12	0.25	0.37	0.48	0.58	1.12	1.25	1.35	1.45	27	גדי סרטן
	6	0.11	0.22	0.33	0.41	0.49	1.3	1.16	1.25	1.34	24	
	9	0.10	0.20	0.30	0.36	0.42	0.55	1.8	1.16	1.23	21	
	12	0.9	0.18	0.26	0.31	0.35	0.47	0.58	1.5	1.12	18	
	15	0.7	0.14	0.21	0.26	0.29	0.40	0.49	0.55	1.0	15	
	18	0.6	0.12	0.17	0.20	0.22	0.31	0.40	0.45	0.49	12	
	21	0.5	0.9	0.13	0.16	0.15	0.23	0.30	0.34	0.37	9	
	24	0.3	0.6	0.9	0.9	0.9	0.15	0.20	0.22	0.24	6	
	27	0.1	0.3	0.4	0.4	0.4	0.7	0.10	0.12	0.13	3	
	30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	

Table 17 (following): Deviation of the right ascension of stars that have a latitude.

יח לוח שינוי מראה הירח באורך וברוחב לעת הראייה

רוחב המדינה 32		רוחב המדינה 36		רוחב המדינה 39		רוחב המדינה 42		רוחב המדינה 45		רוחב המדינה 48		רוחב המדינה 51		רוחב המדינה 54		
רוחב	אורך	רוחב	אורך	רוחב	אורך	רוחב	אורך	רוחב	אורך	רוחב	אורך	רוחב	אורך	רוחב	אורך	מזלות
I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	
9	59	13	59	16	58	19	57	22	56	25	54	28	53	31	52	טלה
10	60	16	58	19	57	22	56	25	55	28	53	31	52	33	50	שור
16	58	25	56	27	54	30	52	33	50	35	49	38	47	40	45	תאומים
27	53	35	49	38	47	40	46	42	42	45	40	47	38	48	35	סרטן
38	43	45	40	47	38	49	35	50	32	52	30	54	27	55	24	אריה
44	37	50	33	51	31	53	28	54	25	56	22	57	19	58	16	בתולה
46	34	52	31	53	28	55	25	56	22	57	19	58	16	58	14	מאזנים
45	34	50	33	51	31	53	28	54	25	56	22	57	19	58	16	עקרב
44	36	45	40	47	38	49	35	50	32	52	30	54	27	55	24	קשת
36	44	35	49	38	47	40	46	42	42	45	40	47	38	48	35	גדי
24	53	25	56	27	54	30	52	33	50	35	49	38	47	40	45	דלי
12	58	16	58	19	57	22	56	25	55	28	53	31	52	33	50	דגים

Table 18: Parallax in longitude and in latitude. The parallax in longitude must be subtracted from the true longitude; it gives the apparent longitude. The parallax in latitude must be added to the true latitude if the true latitude is negative or southern. It must be subtracted from the true latitude if the latitude is positive or northern.

כ לוח היתרונות לחדש ניסן למחזורים ולשנים לדעת שמואל ולדעת רב אדא

לשמואל – למחזורים	ימים. שעות. חלקים	לשמואל – לשנים	ימים. שעות. חלקים	לרב אדא – לשנים: ימים. שעות. חלקים. רגעים
א	0. 1. 485	א	10.21. 204	10.21.121.48
ב	0. 2. 970	ב	21.18. 408	21.18.243.20
ג	0. 4. 375	ג	3. 2. 899	3. 2.651.68
ד	0. 5. 860	ד	14. 0. 23	13.23.773.40
ה	0. 7. 265	ה	24.21. 227	24.20.895.12
ו	0. 8. 750	ו	6. 5. 718	6. 5.223.60
ז	0.10. 155	ז	17. 2. 922	17. 2.345.32
ח	0.11. 640	ח	28. 0. 46	27.23.467. 4
ט	0.13. 45	ט	9. 8. 537	9. 7.875.52
יוד	0.14. 530	יוד	20. 5. 741	20. 4.997.24
כ	1. 4.1060	יא	1.14. 152	1.13.325.72
ל	1.19. 510	יב	12.11. 356	12.10.447.44
מ	2. 9.1040	יג	23. 8. 560	23. 7.569.16
נ	3. 0. 490	יד	4.16.1051	4.15.977.64
ס	3.14.1020	טו	15.14. 175	15.13. 19.36
ע	4. 5. 470	יו	26.11. 379	26.10.141. 8
פ	4.19.1000	יז	7.19. 870	7.18.549.56
צ	5.10. 450	יח	18.16.1074	18.15.671.28
ק	6. 0. 980	יט	0. 1. 485	0. 0. 0. 0
ר	12. 1. 880			
ש	18. 2. 780			
ת	24. 3. 680			

בחשבון שמואל תגרע ז״. ט״. תרמ״ב, ובחשבון רב אדא תגרע ט״ תרמ״ב.

יט לוח מנת ורחב המדינה

מז מורה מזרחית / מע מורה מערבית – לירושלים – ולהוסיף / ולגרוע

שמות המקומות		מנת המדינה: שעות. חלקים	רוחב צפונית: מעלות. חלקים
אלעכסנדריא	מע	0. 364	31. 11
אמשטרדאם	מע	2. 125	52. 23
ברלין	מע	1. 795	52. 33
ברעסלויא	מע	1. 530	51. 3
דאנציג	מע	1. 431	54. 22
האמבורג	מע	2. 28	53. 41
האנאבר	מע	2. 85	52. 30
ווארשויא	מע	0.1026	52. 14
ווינא	מע	1. 493	48. 13
רעגעריג	מע	1. 595	45. 25
טורין	מע	1. 912	44. 50
ירושלים			31. 50
לאנדאן	מע	2. 390	51. 31
לייפציג	מע	1. 840	51. 19
מארנא	מע	1. 657	44. 34
מעטץ	מע	2. 319	49. 7
מענץ	מע	2. 124	49. 54
נאפאליס	מע	1. 408	40. 51
נירנבערג	מע	1. 927	49. 26
ערימבורג	מע	2. 906	55. 58
פאדוא	מע	1. 905	45. 22
פאריז	מע	2. 516	4[illegible]. 50
פלארענץ	מע	1. 589	43. 47
פעקין	מז	5. 435	39. 54
פראג	מע	1. 811	50. 4
פראנקפורט	מע	2. 66	49. 55
קאנדיא	מע	0. 722	35. 19
קאנשטאנטינאפל	מע	0. 464	41. 0
קאפו האנן	מע	1. 846	55. 41
קראקויא	מע	1. 36	50. 10
ראמה	מע	1. 866	41. 54

Table 19: Longitude and latitude of different towns.

Table 20: Excess of the solar years with regard to the Jewish years.

	מולדות	אמצע השמש	גובה השמש
		S o I II	S o I II
עיקר	2. 5. 204	5. 15. 33. 5	0. 11. 36. 36
ר מחזורים	5. 22. 203	0. 16. 48. 58	1. 27. 49. 51
נ מחזורים	1. 11. 590	0. 4. 12. 14	0. 14. 27. 28
ט מחזורים	3. 4. 1035	0. 0. 45. 24	2. 36. 9
טז שנים	7. 12. 701	11. 4. 1. 41	14. 33
ח חדשים	5. 5. 944	7. 22. 51. 14	35
מולד האמצעי	4. 14. 434		
תגרע מנת התיקון	1027		
מולד הנכון	4. 13. 487		
וצריך להוסיף עד רגע המוגבל יום אחד	1.	59. 8	
יוד שעות	10.	24. 38	
נב דקים / נז שניים — העולים	953	2. 8 / 2	
רגע המוגבל	6. 0. 360	1. 5. 38. 32	2. 26. 45. 12

תגרע גובה השמש מן אמצע השמש — — 2. 26. 45. 12.

ונשאר מסלול השמש יו״ד מזלות ח״ מעלות נ״ג חלקים כ״ שניים - 10. 8. 53. 20

ומנתו להוסיף יהיה מעלה אחת ל״א חלקים ז״ שניים — — 1. 31. 7

תוסיף המנה אל אמצע השמש ויוצא מקום השמש האמתי — 1. 7. 9. 39 ר״ל ז״ מעלות ט״ חלקים ל״ט שניים במזל שור. ויהיה נטיית השמש מלוח י״ב צפונית 13. 56. 13

והבדל השקיעה בירושלים מלוח ט״ו יהיה בערך הנטייה — 8. 55. 29

תחליף הבדל השקיעה לדקי שעות מלוח י״ו ויוצא ל״ה דקים מ״ב שניים שיאחר שקיעה האמתי אחר שקיעה האמצעי, וצריך להוסיף זמן זה על זמן המוגבל כדי שיבא לעת הראייה, וצריך להוציא מקום השמש האמתי לעת הראייה. רגע המוגבל היה 6. 0. 360 ואמצע השמש היה 1. 5. 38. 32 (S o I II)

תוסיף. ל״ה דקים / מ״ב שניים 643 — — — — 1. 26 / 2

עת הראייה — 6. 0. 1003 ואמצע השמש — 1. 5. 40. 0

תגרע מקום גובה השמש — — — — 2. 26. 45. 12

נשאר מסלול השמש — — — — — 10. 8. 54. 48

ומנתו להוסיף יהיה מלוח ח״ — — — — 1. 31. 5

תוסיף המנה אל אמצע השמש ויוצא מקום האמתי 1. 7. 11. 5
ר״ל ז״ מעלות י״א חלקים ה״ שניים במזל שור.

ויהיה נטיית השמש מלוח י״ב צפונית — — 13. 56. 42

עלייה הישרה לשמש מלוח י״ד יהיה — — 34. 49. 43

והבדל השקיעה בירושלים להוסיף מלוח ט״ו — 8. 55. 48

תוסיף הבדל השקיעה על עלייה הישרה ויוצא — 43. 45. 31
ר״ל מ״ג מעלות מ״ה חלקים ל״א שניים הנקרא שקיעה עקומה לשמש.

והנה היה ההוספה מן מולד הנכון עד רגע המוגבל יום אחד יו״ד שעות נ״ב דקים נ״ז שניים, ומן רגע המוגבל עד עת הראייה היה ההוספה ל״ה דקים מ״ב שניים, וא״כ יהיה כל הוספה יום אחד י״א שעות כ״ח דקים ל״ט שניים. והוציא לעת הראייה אמצע הירח אמצע מסלול ואמצע הראש.

Table 20 (following). Numerical example dealt with by Maimonides at the end of chapter 17 of *Hilkhot Kiddush ha-Hodesh*. Examination of the visibility of the new moon 20 minutes after the geometrical sunset of the evening beginning on Friday, the second day of the month of Iyar of the year 4938. We assume that the astronomical lunar conjunction coincided with the *molad* in Tishri 4507.

	אמצע הירח	אמצע מסלול	אמצע הראש
	S O I II	S O I II	S O I II
עיקור	5. 15. 33. 5	8. 28. 12. 5	2. 25. 37. 59
ר מחזורים	0. 16. 48. 58	5. 27. 26. 16	1. 25. 9. 0
נ מחזורים	0. 4. 12. 14	7. 14. 21. 34	0. 13. 47. 15
ט מחזורים	0. 0. 45. 24	8. 1. 59. 5	2. 7. 16. 54
ט״ז שנים	11. 4. 1. 41	1. 15. 51. 31	10. 8. 3. 15
ח חדשים	7. 22. 51. 14	6. 26. 31. 56	0. 12. 30. 35
יום אחד	13. 10. 35	13. 3. 54	3. 11
י״א שעות	6. 2. 21	5. 59. 17	1. 27
כ״ח רקים	15. 22	15. 15	4
ל״ט שניים	22	22	
מקומות האמצעים לעת הראייה	1. 23. 41. 16	3. 13. 41. 15	6. 2. 29. 40

מן אמצע הירח תגרע אמצע השמש	1. 5. 40. 0	5. 27. 30. 20
נשאר מרחק הירח מן השמש	0. 18. 1. 16	מקום הראש
וכפלו יהיה מרחק הכפול	1. 6. 2. 32	
מנת מרחק הכפול להוסיף יהיה מלוח ט״	5. 15. 20	וחלק היחוס 4. 3 (I II)
תוסיף מנת זה אל אמצע המסלול ויוצא מסלול הנכון	3. 18. 56. 35	
ומנת מסלול הנכון לגרוע יהיה מלוח יא״	4. 52. 7	ושינוי אלכסון יהיה 2. 39. 0 (o I II)
תוסיף חלק היחוס המכוון אל מנת מסלול הנכון	10. 44	ויוצא חלק היחוס המכוון 0. 10. 44
ויוצא מנת הירח המחובר לגרוע מן אמצע הירח	5. 2. 51	
ויהיה מקום הירח האמתי	1. 18. 38. 25	1. 18. 38. 25
תגרע מקום הראש מן מקום הירח האמתי	5. 27. 30. 20	מקום השמש האמתי 1. 7. 11. 5
ונשאר מסלול הרוחב	7. 21. 8. 5	קשת האורך 11. 27. 20
ויהיה רוחב הירח דרומית מלוח יו״ד	3. 53. 24	
שינוי מראה האורך לגרוע יהיה מלוח יח״	1. 0. 0	
ושינוי מראה הרוחב להוסיף יהיה	10. 0	
ויוצא מקום הירח הנראה	1. 17. 38. 25	
ורוחב הירח הנראה דרומית	4. 3. 24	4. 3. 24 (o I II)
ויהיה נטיית מקום הירח הנראה מלוח יב״ צפונית	17. 7. 53	תגרע גליזת הנטייה 0. 10. 17
רוחב הירח המתוקן דרומית לגרוע	3. 53. 7	רוחב הירח המתוקן 3. 53. 7
ויוצא נטיית הירח צפונית	13. 14. 46	
עלייה הישרה למקום הירח הנראה מלוח יד״	45. 10. 3	
גליזת עלייה הישרה מלוח יז״ חלק שני להוסיף	1. 11. 20	
ויוצא עלייה הישרה לירח	46. 21. 23	
הבדל השקיעה בירושלים מלוח ט״ו להוסיף	8. 27. 51	
ויוצא שקיעה עקומה לירח	54. 49. 14	
שקיעה עקומה לשמש היה	43. 45. 31	
ונשאר קשת הראייה	11. 3. 43	
תחבר קשת האורך	11. 27. 20	
ויהיה קיבוץ המעלות משני הקשתות	22.	

ובעבור שהיה בקשת האורך איזה חלקים יתר על המעלות תדע שיראה הירח באותו לילה בירושלים.

Table 20 (following). The time elapsed from the beginning of Tishri 4507 until the beginning of Iyar 4938 is 22 cycles of 19 years + 13 years + 8 months. From Tables 1, 2 and 3 we find the yitronot for 20 cycles, 2 cycles, 13 years and 8 months, respectively: 903. 59; 90. 24; 30. 46; and 1. 32, all in all 1026 41/76 rounded off to 1027 *halakim* at the top of the first part of Table 20 under the item: מנת התיקון.

3. Table 1: Mean movement of the sun and its apogee, of the moon, its anomaly and its ascending node, *molad* and corrections for years in the 19 year cycle.

1st column: number of cycles.
2nd column: *molad*; residue corresponding to the span of time defined in the 1st column for the calculation of the *molad*.
3rd column: correction for the astronomical mean conjunction corresponding to the span of time defined in the 1st column. The mean astronomical conjunction does not coincide perfectly with the molad because the synodic mean lunar month is slightly shorter than the Jewish month of 29d 12h 793p.
4th column: variation of the longitude of the mean sun and the mean moon at the astronomical mean conjunction during the span of time defined in the first column.
5th column: variation of the sun's apogee during the span of time defined in the first column.
6th column: variation of the moon's mean anomaly during the span of time defined in the 1st column.
7th column: variation of the moon's mean position of the head or ascending node during the span of time defined in the 1st column. The movement of the ascending node is retrograde. All the figures of this column are negative but this is also the case of the radix, i.e. the figure of the first line representing the position at the first conjunction.
1st line: gives the radices, i.e. the different parameters at the epoch, i.e. the astronomical mean conjunction corresponding to the *molad* of *Beharad*. The addition of the radix of each parameter with the value of the variation of this parameter during the span of time corresponding to a certain line gives the value of this parameter after the end of this span of time counted from the mean conjunction corresponding to *Beharad*.

4. Table 2: Mean movement of the sun and apogee, of the moon, its anomaly and its ascending node, *molad* and corrections for years in the 19-year cycle.

The columns have the same meaning as above.

5. Table 3: Mean movement of the sun and its apogee, of the moon, its anomaly and its ascending node, *molad* and corrections for months (synodical lunar months of 29d 12h 44m 3.3s).

The columns have the same meaning as above.

These three tables allow finding the astronomical mean conjunction corresponding to any *molad* and calculating the mean longitude of sun and moon, the position of the solar apogee, the mean anomaly of the moon and the mean ascending node at any astronomical mean conjunction or half a month later at mean full moon.

Far before Baneth,[5] Raphael Hanover had considered that the mean velocity of the variation of the astronomical parameters of the sun and moon adopted by Maimonides could be deduced with the highest accuracy from Maimonides' data for a span of time of 10,000 days.[6] On this basis, it can be calculated that the rate of variation of these parameters during a day is:

The mean movement of the sun: 0° 59' 8" 19''' 48'''' = 3,548.33"/d.

The mean movement of the moon: 13° 10' 35" 1''' 48'''' = 47,435.03"/d.

The relative movement of sun and moon: 43,886.7"/d

The apogee of the sun: 0° 0' 0" 9''' 0'''' = 0.15"/d

The mean anomaly of the moon: 13° 3' 53" 55''' 48'''' = 47,033.93"/d.

The ascending node of the moon: – 0° 3' 10" 37''' 48'''' = –190.63"/d

The Jewish month: 29d 12h 793p = 29.530 594 135 802 469 136 d = 765,433 p.

The astronomical month: 1,296,000 / 43,886.7 = 29.530 586 715 337 448d =

5 Eduard Baneth (1855-1930) authored two authoritative works on Maimonides' *Hilkhot Kiddush ha Hodesh*: he considered that Maimonides had improved the data of Al-Battani, and had reached an exceptional precision for the tropical year. This seems however illusory: Maimonides never departed from the value of Al-Battani; see the next note.

6 See J. Ajdler, *Hilkhot Kiddush ha-Hodesh al-pi ha-Rambam*, Sifriati 1996, pp. 126-127 and pp. 230-232, where this subject is discussed thoroughly. Hanover's assumption seems artificial and it is not likely that Rambam changed anything with regard to al-Battani's values. The fact that we succeeded in justifying (see *B.D.D*. 16) to an accuracy of a minute the instant of the epoch of Maimonides from the tables of Al-Battani proves without any doubt that Maimonides rigorously follows the movement's parameters of Al-Battani.
Thus, Maimonides' correct parameters must be deduced from his data for 10,000 days. In fact, the comparison of the sygyzie tables of al-Battani and Ptolemy prove that their mean lunation is the same as the Jewish month i.e. 29-1-793. Therefore, the distance between the *molad* and the astronomical mean conjunction is a constant. The date of 4507 is a pure fiction.

765,432.807662 p.
The difference between these two different values is the correction (tikkun) considered in Tables 1-3.

It represents 0.192 338 423 3 p = 0.634 716 895 9 s = 0.000 007 420 465 021 d.

The principle of the correction or tikkun is to find the astronomical mean conjunction based on the following element: the molad of Nissan 4938 was on 3 – 1 – 721 but the corresponding astronomical mean conjunction resulting from Maimonides' data was on 3 – 0 – 775. There is thus a difference of 1026 p. We can conclude that the mean conjunction and the molad coincided 1026 / 0.192 338 423 p = 5334.3476 months before. Hanover considers that the coincidence happened on molad Tishri 4507. The number of elapsed years between the beginning of 4507 and the beginning of 4938 is: 16 years in the 239th cycle, 21 complete cycles and 16 years in the 260th cycle and the number of elapsed months between the beginning of 4507 and the beginning of Nissan 4938 is thus 235 * 21 + 32 * 12 + 6 + 6 + 7 = 5338 months. Hanover makes a slight approximation in order to create an easy calculation, the coincidence occurring in fact only during Tevet 4507.[7] He makes a second approximation in considering the span of time as 431 years plus 7 months, equal to 22 cycles + 13 years + 7 months or 22 * 235 + 13 * 12 + 4 + 7 = 5337 months instead of 5338 months.[8]

In one cycle the tikkun is 235 * 0.1923384233 = 45.19945294755p. Hanover writes: 45 p 12/60.

In 500 cycles it is 500 * 45.19945294755 = 22599.7647 p = 20h 999.7647 p or 20h 999p 45.8843/60. Hanover writes correctly 20h 999p 46/60.

The mean movement of the sun

The mean movement is 3548.33"/d. In one cycle of 19 years, the movement of the sun is [29.530 586715337448 * 235 * 3548.33]mod 1,296,000 = 302.688 514 292 11".

Hanover writes in his table 5' 3". After 500 cycles the movement is 151 344.2571" or 42° 2' 24.2571". Hanover writes correctly 1^s 12° 2' 24". 1^s =30° in the works of the Ancients.

7 This approximation introduces an error of nearly four months.

8 This approximation introduces an error that is no greater than one month. The error is thus – 1 month, 0 month or + 1 month.

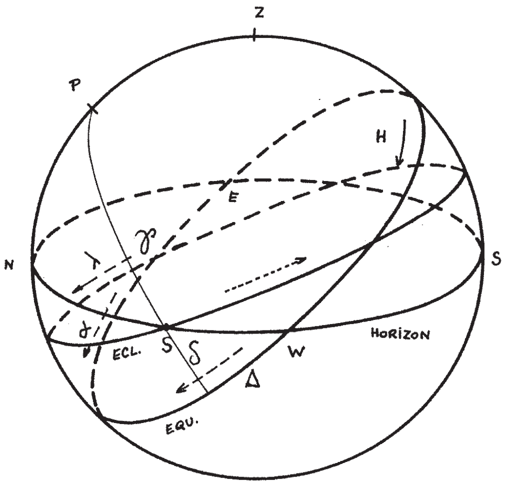

Figure 1. The celestial sphere seen from abroad. The western horizon, the equator and the ecliptic, the direct movement of the sun and the retrograde diurnal movement

Mean movement of the moon

The mean movement of the moon is 13° 10' 35.03" or 47 435.03"/d. In one 19-year cycle, the movement of the moon is:
[29.530 586 715 337 448 * 235 * 47 435.03] mod 1,296,000 =1,104,793.880 608 350 43"
It corresponds to 306° 53' 13.8806"; Hanover writes correctly 10^s 6° 53' 14".
After 500 cycles, the movement of the moon is:
[500 * 1,104,793.88060835043]mod 1,296,000 = 300,940.304175215".
It corresponds to 83° 35' 40.304 175 215". Hanover writes: 2^s 23° 35' 41". The last figure is rounded off incorrectly.

The above elements suffice to understand the contents of these first three tables and the method of their construction. One can also see the amount of work and the amazing calculation skills that were required in their construction.

6. Table 4: Transformation of *halakim* in hexadecimal fractions of hour.
7. Table 5: Mean movements of the sun, moon, moon's anomaly and ascending node for days.

8. Table 6: Mean movements of the sun, moon, moon's anomaly and ascending node for hours.
9. Table 7: Mean movements of the sun, moon, moon's anomaly and ascending node for minutes.

These tables are the prolongation of the first tables and do not require additional explanations.

10. Table 8: Quota of the sun's anomaly in function of the anomaly.

The understanding of this table requires the study of the solar model of the ancients.
In Fig. 2, H is the position of the sun in its orbit, H_1 is the apparent position of the sun as seen from the earth and H_2 is its mean position. P is the perigee and K is the apogee. Angle <KEH> is the true anomaly; angle <KCH> is the mean anomaly α, and angle <EHC> is the quota of the anomaly β°.

The true anomaly is the angle <KEH> = <KCH> - <EHC> = α-β°. If we add the longitude of the apogee to both members of the relation, we get then L° = l° - β°, where L° is the true longitude of the sun and l° is the mean longitude of the sun.

If EC=b, CH=a and EH=c then e° = b /a. We have further $c \sin \beta° = b \sin \alpha$

$$c \cos \beta° = a + b \cos \alpha$$

Dividing these relations member by member: $$\tan \beta° = \frac{e° \sin \alpha}{1 + e° \cos \alpha} \quad (1)$$
Where e° = 0.0347 is the eccentricity of the sun's orbit.
For example, if α = 70° we find β° = 1° 50' 45". Hanover writes β° = 1° 51'.
The anomaly is maximum when sin α = - e°, i.e. when α = 91.9886°, β° is then 1°; 59' 19".
The true position of the sun varies thus around its mean position by an angle β° which is always less than two degrees. This angle β° was called quota of the anomaly and it corresponds to our modern equation of the center. $$L° = l° - \beta° \quad (2)$$

11. Table 9: Quota of the double elongation (prosneusis angle p) and the proportion c for the moon in function of the double elongation.

The explanation of this table will be examined together with Table 11.

12. Table 10: The moon's latitude in function of the argument of latitude.

If Ω is the longitude of the ascending node and λ and β are the longitude and latitude of the moon, then the latitude of the moon is given by the relation
$\tan \beta = \tan 5° * \sin (\lambda\text{-}\Omega)$ in which λ-Ω is the argument of latitude.

13. Table 11: Quota of the true anomaly q and the angle s (*shinui alakhson*) in function of the true anomaly.

The understanding of these tables requires the study of the lunar model of the ancients. The astronomers of the 18th century were still acquainted with the

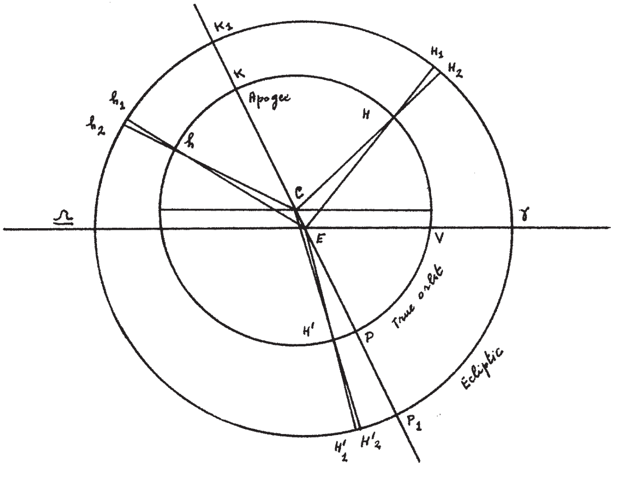

Figure 2. The model of the sun's movement. The elongation is about 25°

model of the ancients.[9] The aim of this model is to calculate the true position of the moon from its mean position.

The apparent movement of the moon happens counterclockwise on a great circle inclined on the ecliptic by an angle of about 5°. This inclination generally is neglected, except for the study of the moon's latitude. This great circle intersects the great circle of the ecliptic at two points, the ascending node, when the latitude

9 This appears clearly from the study of the two greatest French astronomers of the 18th century: Lalande and Delambre.

of the moon becomes positive and the descending node when its latitude becomes negative. Both points have a retrograde movement.

We have represented the model of the moon's movement on Figs. 3 and 4. O is the mean moon, M is the true moon. M moves in a retrograde movement, i.e. clockwise, along a small circle of radius r at the velocity of 13°; 03' 53.93". Its center O moves counterclockwise (direct movement) on a great circle of radius R and of center C, different from E, the earth. It is called the eccentric or the deferent. The diameter EO, the apse line, joining the earth to the mean moon intersects the epicycle at points A and T, A being the most removed point from the earth. The point of intersection of the indicator EM with the ecliptic is the true

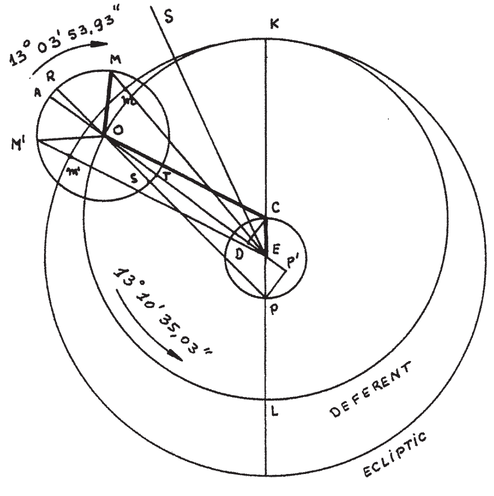

Figure 3. The model of the moon's movement

position of the moon. The vector ES represents the direction of the mean sun. The angle <OES> between the mean sun and the mean moon is called the elongation η. The cinematic model of the ancients postulates that <OES> = <SEC> or that <OEC> = 2η; it is called the double elongation. Point C turns around E clockwise (retrograde movement). Point P is the symmetric of C in regard of E; it is the prosneusis point. P0 intersects the epicycle at R. A is the true apogee and R is the mean apogee of the epicycle. The angle <ROM> is the moon's mean anomaly.

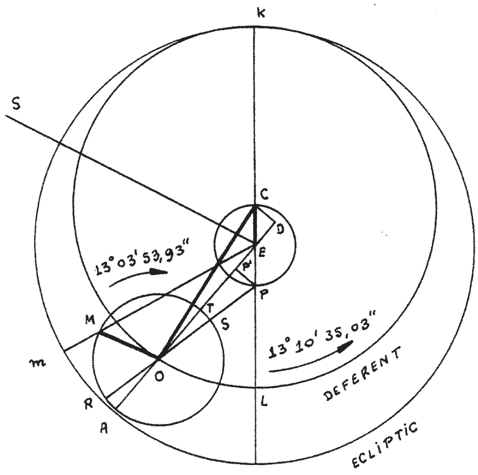

Figure 4. The ancients' model of the moon's movement.
The elongation is about 62°

<AOR> is the quota of the double elongation or the prosneusis arc p. The angle <AOR> is the moon's true anomaly. The true anomaly is thus the mean anomaly plus, or less, the quota of the double elongation. Finally, the angle <OEM>, which represents the difference between the mean position of the moon O and the true position of the moon m, is the quota of the true anomaly. Point K is the apogee of the mean moon's movement on the eccentric and point L is the perigee of the mean moon's movement on its eccentric.

According to Al-Battani, followed by Maimonides,
e(= EC = PE = 10^p 19' = 10.3167.
The radius of the ecliptic is fixed arbitrary to 60p.[10]
The radius of the epicycle is r = 5^p 15' = 5.25.
The radius of the eccentric is R= 60^p – 10p 19' = 49^p 14' = 49.6833.
The distance from the earth to the apogee of the eccentric is EK = 60^p.
The distance from the earth to the perigee of the eccentric is
EL = 39^p 22' = 39.3667.

10 For the ancients, 60 plays the same role as 100 for us, thus 60p has the same meaning as 100%, p means units, it allows distinguishing from degrees. 60p represents the reference distance; it is a relative and not an absolute distance.

DAILY MOTION OF	RELATIVE TO	DIRECTION	NUMERICAL VALUE
E S	E γ	EAST	ω_O = 0°; 59' 8'',33
E O	E S	EAST	ω_S = 12°; 11' 26'',70
E O	E γ	EAST	$\omega_($ = 13°; 10' 35'',03
E K	E S	WEST	ω_S = 12°; 11' 26'', 70
E K	E O	WEST	$2\omega_S$ = 24°; 22' 53'', 40
E K	E γ	WEST	$\omega_S - \omega_O$ = 11°;12' 18'',37
O M	O R	WEST	ω_a = 13°; 03' 53'',93
E 0	E Ω	EAST	ω_d = 13°; 13' 45'',66
E K	E Ω	WEST	$2\omega_S - \omega_d$ = 11°; 09' 07'',74

Figure 5. Movement of the moon: movement of the different vectors of Figures 2 and 3

$$\frac{EL}{EK} = \frac{39.3667}{60} = 0.6561$$
$$\frac{r}{R} = \frac{5.25}{49.6833} = 0.1057$$

Determination of the true moon from the mean moon

The data of the problem are the mean anomaly <ROM> and the elongation <OES>.

We want to find the angle <OEM>, the quota of the true anomaly.

First step: in the triangle OPE, PP' is perpendicular to OE.

$$\tan p = \tan <EOP> = \frac{PP'}{P'O} = \frac{PP'}{P'E + EO} = \frac{PE \sin < PEO >}{EO - PE \cos < PEO >}$$

With <PEO> = 180°-2η; PE = EC = e(and EO = ρ.
This relation is true in all the cases of figure. In Fig 2: cos (<PEO>) is negative while in Fig 3., it is positive. Therefore:

$$\tan p = \frac{e(\sin 2\eta}{\rho + e(\cos 2\eta} = \frac{\dfrac{e(\sin 2\eta}{\rho}}{1 + \dfrac{e(\cos 2\eta}{\rho}} \qquad (3)$$

In the triangle OEC: $\rho = OE = OD + DE = \sqrt{OC^2 - DC^2} + DE$

OC = R; DC = EC sin<CEO> = e(sin2η; DE = EC*cos<CEO> = e(cos2η and therefore

$$\rho = \sqrt{R^2 - (e(\sin 2\eta)^2} + e(\cos 2\eta \qquad (4)$$

In the triangle OEM: angle <AOM> = <AOR> + <ROM> p + m
OM = r
EM sin β = r sin (m+p)
EM cos β= EO + r cos (m+p).
Dividing member by member:

$$\tan \beta = \frac{r \sin(m+p)}{\rho + r\cos(m+p)} \qquad (5)$$

and finally

$$L(= l(- \beta \qquad (6)$$

If η = 0, we are at the mean conjunction and the mean moon is in K, the apogee of the eccentric: ρ = R + e(and p = 0.
If η = 90°, we are at the quadrate and ρ = R – e(and p = 0.
If η = 180°, we are at the mean opposition and the mean moon is in K, the apogee of the eccentric: ρ = R + e(and p = 0.

Example: if 2η = 120° then: $\frac{e(}{R} = 0.2076$, $\frac{\rho}{R} = 0.8799$ (4) and therefore $\frac{e(}{\rho} = 0.2404$.

(3) gives then tan p = 0.2317 and p = 13°; 02' 17".
In Table 9, Hanover gives for 2η = 120° a quota of the double elongation of 13°; 02'.
If we consider now that the true anomaly is 95° then equation (5) gives:

$$\tan \beta = \frac{5.25 \sin 95^\circ}{0.8799 * 49.6833 + 5.25 \cos 95} = 0.1209, \text{ hence } \beta = 6°; 53’ 37”.$$

In Table 11, Hanover gives the quota of the true anomaly q = β(2η = 0) and the angle s defined as q +s = β(2η= 180°).
In Table 9 he gives the angle p or the quota of the double elongation and the proportion c defined by q + c*s = β(2η).

If 2η = 0, then ρ = R+e(= 60 and $\tan q = \frac{5.25 \sin 95°}{60 + 5.25 \cos 95°}$. q = 5.0198° = 5°; 01' 11".

If 2η = 180° then ρ = R-e(= 39.3667 and $\tan(q+s) = \frac{5.25 \sin 95°}{39.3667 + 5.25 \cos 95°} = 0.1344$.

q + s = 7.6556° = 7°; 39' 20". s = 2°; 38' 09".

We have seen that β (2η=120°) = 6°; 53' 37" = q + c*s.

$c = \frac{6°;53'37"-5°;01'11"}{2°;38'09"}$[mo6]= $0.7109 = \frac{43}{60}$.

Hanover gives in Table 9: p = 13°; 02' and c = 43

In Table 11: q = 5°; 00' and s = 2° 39'

We worked with the data of Al-Battani; it is not impossible that Hanover had slightly different coefficients explaining a difference of rounding off for q and s. The tables of Hanover show that q_{max} = 5° and $(q+s)_{max}$ = 7°; 39'. Thus, at the conjunction and the full moon, the true moon differs from its mean position by an angle inferior to 5° but in the quadrant it differs by an angle inferior to 7°; 39'. This corresponds to the effect of an equation[11] called the evection; its greatest importance is found in the quadrant; this was already known by Hipparchus and quantified by Ptolemy. The rules of the signs of the tables can be deduced from the different figures. In Table 11 for a true anomaly of 70° there is probably a misprint and the quota of the true anomaly 4°; 33' must be changed to 4°; 34' as it appears from the direct calculation.

14. Table 12: Declination of the sun in function of its longitude.

The declination of the sun in function of its longitude is given by the formula:
sin δ = sin ε * sin λ where ε = 23.5° is the inclination of the ecliptic with regard to the equator, λ is the sun's longitude and δ is the required sun's declination.
If for example λ = 58°, δ = 19°; 45' 53". Hanover writes 19°; 46'.
The title of this table ascertains that this table can also be used for the moon. This is a mistake. The declination of the moon would require the formula:
$\sin \delta = \sin \beta * \cos \varepsilon + \cos \beta * \sin \varepsilon * \sin \lambda$ (7);

11 This word is commonly used in the 18th century with the meaning of correction.

15. Table 13: Deviation of the declination of the stars that have a latitude in function of their longitude and latitude.

A similar table can be found in the Astronomy of Lalande: "quantité à ôter de la latitude d'une planète pour avoir la différence entre sa déclinaison et celle du point correspondant de l'écliptique." Let us consider formula (7) in the following example:
Data: $\lambda = 21°$; $\beta = 9°$.
If $\beta = 0$, then formula (7) gives $\delta = 8.2156°$ or 8°; 12' 56". Hanover gives 8°; 13' in Table 12.
If $\beta = 9°$, then formula (7) gives $\delta = 16.5349°$ 16°; 32' 06". The difference is thus 8.3193° or 8°; 19' 09".
Thus, the star has a declination of 16°; 32' 06" while the point of the ecliptic with the same latitude has a declination of 8°; 12' 56". The quantity to add to 8°; 12' 56" to get the latitude of the star is thus 8°; 19' 09". Hanover gives in his table 8°; 19'.

16. Table 14: Right ascension of the points of the ecliptic.

The formula is: $\tan \alpha = \tan \lambda * \cos \varepsilon$
If $\lambda = 114°$, i.e. 24° in Cancer, we find $\alpha = 115°$; 53' 57". Hanover gives 115°; 54'.

17. Table 15: Set lag for different places in function of the sun's declination, see Figures 6 and 7.

The hour angle of sunset is given by $\cos H = - \tan \varphi * \tan \delta$. The set lag is the difference between the time of sunset and 6 p.m., the time of sunset at the equator; it is thus $H – 90°$

Now $\sin (H – 90°) = - \sin (90° – H) = - \cos H = \tan \varphi * \tan \delta$.

Thus $\sin \Delta = \tan \varphi * \tan \delta$.

This can also be demonstrated straight. If we consider at sunset, the rectangular spherical triangle delimited by the arc of declination passing through the sun, the equator and the western horizon, the two sides of the right angle are δ and Δ and the angle opposite to δ is $90° - \varphi$. We can thus write in this triangle
$\sin \Delta = \tan \delta / \tan (90° - \varphi) = \tan \varphi * \tan \delta$.

If $\Delta > 0$ then the sunset is after 6 p.m., and if $\Delta < 0$ then the sunset is before 6 p.m. Example: If we are in Copenhagen with $\varphi = 55°$; 14' and $\delta = 23.5°$ (solstice), we find that $H = 129.5694°$ at sunset, corresponding to 20h 38m 17s.

The set lag is 2h 38m 17s. Now $\sin \Delta = \tan \varphi * \tan \delta$ gives $\Delta = 39.5694°$ or 39°; 34'10" corresponding to 2h 38m 17s. Hanover gives a set lag of 39°; 34'.

The ancients added algebraically $\alpha + \Delta$ at sunset and got the distance, calculated at sunset, between γ, the vernal point, and the western horizon. They called it the oblique sunset or the Maghrab, corresponding to the right ascension of the point of the equator setting together with the sun. It corresponds to Ts – 90°, where Ts is the sidereal time.

Today, we calculate $H = \Delta + 90°$; it is the hour angle at sunset and it gives directly the true time at sunset. Similarly, we calculate today the sidereal time Ts, the hour angle of the vernal point at sunset: $Ts = \alpha + H = \alpha + \Delta + 90°$. These two relations giving H and Ts are also valid at the setting of any celestial body. The ancients considered also the distance, at sunrise, on the equator of the vernal point γ to the eastern horizon corresponding to the right ascension of the point of the equator rising together with the sun. They called it the oblique sunrise or Matala, equal to $\alpha - \Delta$. Indeed, if sunset is at 7 p.m., sunrise is at 5 a.m.

The difference between the oblique sets of moon and sun is of course equal to the difference of the sidereal times of the sets of moon and sun; it corresponds to the set lag between moon and sun.

18. Table 16: Expression of arcs of the equator in time.

360° corresponds to 24h = 1440m; thus 1° corresponds to 4 m.

19. Table 17: Deviation of the right ascension of stars that have latitude.

We find a similar table in the Astronomy of Lalande: "équation pour réduire les ascensions droites des points de l'écliptique à celles des astres qui ont une latitude."

We consider the formula $\tan \alpha = \dfrac{\sin \lambda * \cos \varepsilon - \tan \beta * \sin \varepsilon}{\cos \lambda}$. (8)

Example:

Data: $\lambda = 45°$ and $\beta = 9°$. If $\beta = 0°$ then $\alpha = 42.5227° = 42°; 31' 27"$.

If $\beta = 9°$ then $\alpha = 39.6161° = 39°; 36' 58"$.

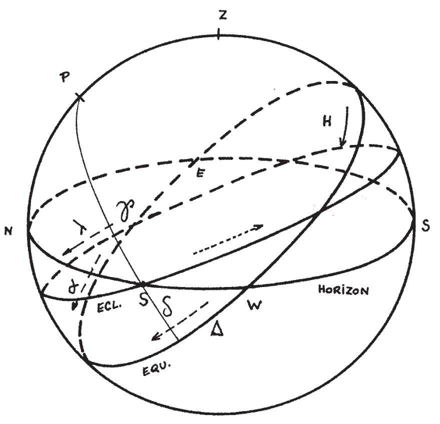

Figure 6. Representation of sunset. On this figure $\varphi = 32°$, $\lambda_0 = 130°$ (beginning of August); $\alpha = 132.46°$
$\delta = 11.79°$. H = 101.56°, $\Delta = 11.56° = 46$m. Sunset is at 6h 46m p.m. Ts = α + H = $\alpha + \Delta + 90 = 234.02°$
The Maghrab is the arc of the equator setting together with γS i.e.: $\gamma W = \alpha + \Delta = 144.02°$

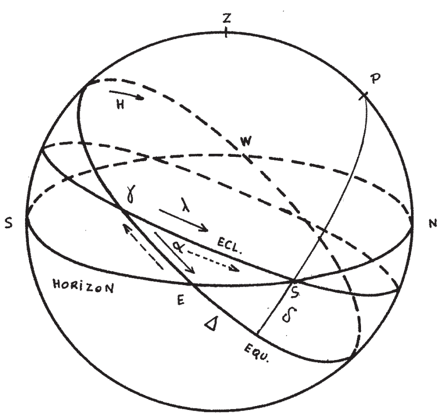

Figure 7. Representation of sunrise. On this figure $\varphi = 32°$, $\lambda_0 = 55°$ (about May 15); $\alpha = 52.64°$, $\delta = 19.06°$.
H = – 102.47°, $\Delta = 12.47° = 50$m. Sunrise is at 5h 10m a.m. Ts = α + H = $\alpha - \Delta - 90 = -49.83° = 310.17°$.
The Matala is the arc of the equator rising together with γS i.e.: $\gamma E = \alpha - \Delta = 40.17°$

Thus, the difference is 2°; 54' 24". The arc to subtract from the right ascension of a point of the ecliptic to get the right ascension of a star with the same longitude and a latitude of 9° is 2°; 54' 24". Hanover gives 2°; 55'.

20. Table 18: The parallax in longitude and in latitude of the moon.

The problem of the parallax is one of the great problems raised by Maimonides' *Hilkhot Kiddush ha-Hodesh*, and it remains unsolved today. Hanover wrote in chapter 84 of *Tekhunat ha-Shamayim* that Maimonides' table of parallax can only be understood under the following assumptions: the calculation is made at the moment of vision, i.e. twenty minutes after apparent sunset and with a double elongation of 31°. This second assumption implies that ρ/R remains constant in the different calculations and that the horizontal parallax has the value of 0.9838° = 59' 02" and $\sin \Pi_h = 0.172$.[12] In fact, Hanover must not have completely solved the problem because the table of parallax for the other localizations, different from Jerusalem, was calculated differently than those values adopted from Maimonides for Jerusalem. Hanover's table of parallax for these different localizations has a typical symmetry that proves that it is calculated at the moment of the geometrical sunset. The calculation of the lunar parallax can be achieved through the formula of Von Littrow.

$$\tan \lambda' = \frac{\sin\lambda * \cos\beta - \sin\Pi * (\sin\varphi * \sin\varepsilon + \cos\varphi * \cos\varepsilon * \sin\theta)}{\cos\lambda * \cos\beta - \sin\Pi * \cos\varphi * \cos\theta} \qquad (9)$$

$$\tan \beta' = \frac{\cos\lambda' * (\sin\beta - \sin\Pi * (\sin\varphi * \cos\varepsilon - \cos\varphi * \sin\varepsilon * \sin\theta))}{\cos\lambda * \cos\beta - \sin\Pi * \cos\varphi * \cos\theta} \qquad (10)$$

In these formulas, λ is the geocentric ecliptic longitude of the moon,
β is the geocentric ecliptic latitude of the moon,
λ' is the topocentric longitude of the moon,
β' is the topocentric latitude of the moon,
φ is the observer latitude,
ε is the obliquity of the ecliptic,
θ is the sidereal time,
λ-λ' is the parallax in longitude and β-β' is the parallax in latitude.

12 See Ajdler, *Hilkhot Kiddush ha-Hodesh al-pi ha-Rambam*, p. 145.

Let us check Hanover's table of parallax, which, for Jerusalem, reproduces the table of Maimonides with slight corrections.

1. Jerusalem, zodiacal sign of Taurus. We assume: $\varphi = 32°$, $\lambda° = 60°$ and $\lambda(= 75°$ and $\beta = 0$. In contradiction to Hanover, we adopt for the horizontal parallax $\Pi = 1.0208°$ and $\sin \Pi = 0.178$. It is indeed impossible to have a value of parallax in longitude of 60' if the horizontal parallax is only 59' 02" as proposed by Hanover. Under these assumptions, (7) gives $\delta = 20.2017°$ and (8) gives $\alpha = 57.8069°$. The hour angle of the sun when the depression of the sun is 1° (apparent sunset of Maimonides)[13] is 104.5874°. At the moment of vision, the hour angle is $H = 109.5874°$ and the sidereal time is $\theta = \alpha + H = 57.8069 + 109.5874\ 167.3943°$. We find $\tan \lambda' = 3.5061$ and $\lambda' = 74.0809°$. The parallax in longitude is then $\Delta\lambda =$ 55' 09" instead of 58' given by Maimonides. $\Delta\beta = \beta - \beta' =$ 25' 19" instead of 16' given by Maimonides. We made the same calculation 20m after the geometrical sunset and found $\Delta\lambda =$ 55' 10" and $\Delta\beta =$ 24' 52". At the moment of the geometrical sunset, we found: $\Delta\lambda =$ 56' 16" and $\Delta\beta =$ 23' 09". The calculation of Maimonides' table of parallax remains a conundrum. The fact that Hanover established the rest of the table, for other latitudes than Jerusalem on a different basis, proves that he too could not justify Maimonides' data.

2. $\varphi = 42°$ in the sign of Taurus. We assume thus $\varphi = 42°$, $\lambda° = 60°$, $\lambda(= 75°$, $\beta = 0°$ and $\Pi = 1.0208°$. The calculation is certainly performed at the moment of the geometrical sunset because of the symmetry of the table. We find $H = 109.3486°$ and $\theta = 167.1555°$.
$\Delta\lambda =$ 49' 41" instead of 52' and $\Delta\beta =$ 33' 40" instead of 30'.

Conclusion: We can fully justify neither the table of Maimonides ($\varphi = 32°$) nor the tables calculated by Hanover for different latitudes.

21. Table 19. For different towns: the longitude, expressed in hours and halakim, and the latitude.
22. Table 20: The excess of the solar years (according to Samuel and Adda) with regard to the Jewish years of 12 and 13 months.

13 See Ajdler, "The Equation of Time in Ancient Jewish Astronomy," in *B.D.D.* 16, notes 61 and 71.

This table gives the difference between the length of the solar years and the length of the Jewish years. The solar year according to Samuel has a length of 365.25 days; it corresponds to the Julian year. The solar year of Adda is 1/19 of 19 solar years equal to 235 Jewish months of 29d 12h 793p.

The table of the cycle concerns only the years of Samuel. It is based on the well known data that 19 solar years exceed 19 Jewish years of 235 months by 1h 485p. Thus, for 400 cycles the excess is 400 * (1h 485p) or 24d 3h 680p.

Column of the years according to Samuel:

The different figures are calculated as follow:
12 Jewish months = 354d 8h 876p.
13 Jewish months = 383d 21h 589p.
1 year exceeds 12 months by 365.25 – 12*(29-12-793) = 10d 21h 204p.
2 years exceed 24 months by 2*365.25 – 24*(29-12-793) = 21d 18h 408p.
3 years exceed 37 months by 3*365.25 – 37*(29-12-793) = 3d 2h 895p.
and so on

8 years exceed 99 months by 8*365.25 – 99*(29-12-793) = -- 1d 12h 747p.
This is the only case where the civil years are shorter than the Jewish years.

Column of the years according to Adda:

The figures of this column are slightly different from those of the column according to Samuel. Indeed, the year of Adda is 365d 5h 997p 48/76 instead of 365d 6h, thus a difference of 82p 28/76.

On Nissan 1 AM1 the molad was	2-5-204 – 2 – 4 – 438 =	4 – 9 – 642
The *tekufah* was 7-9-642 before		– 7 – 9– 642
Thus		4 – 0 – 0

Thus, tekufat Nissan was on Tuesday evening at 18h, corresponding in the Jewish calendar to Wednesday 0h.

Example of calculation of the *tekufah* of Nissan 5517 according to Samuel or R. Adda

1. Samuel

The time elapsed from molad *Beharad* until Nissan 5517 is 5516 years and 6 months or 290 cycles of 19 years and 6 months. It is easy to calculate the *molad* of Nissan 5517 with the data of Tables 1-3. We find the *molad* on 1d 15h 754p. The total of the *yitronot*, the excess of the Jewish lunar years on the 5516 Julian years of 365.25d, deduced from Table 20, amounts to 23d 17h 968p. We subtract from this number 7d 9h 642p. corresponding to the advance of the first *tekufah* of Nissan of year 1 AMI on *molad* Nissan year 1 AMI. We find 16d 8h 326p, representing the delay of the *tekufah* with regard to the *molad* Nissan calculated above. This *tekufah* falls then about Nissan 16. Adding 16d 8h 326p to 1d 15h 754p, we find 18d 0h 0p equivalent to 4d 0h 0p. The *tekufah* was thus on Wednesday at 18h, exactly at the moment of the *tekufah* of Nissan 1 AMI. This coincidence results from the fact that 5516 is a multiple of 28, therefore the *tekufah* of Nissan 5517 is on the same weekday and at the same hour as it was in year 1 AMI.

2. R. Adda

The year 5517 is the seventh year of a cycle of 19 years. The number of elapsed years is 290 * 19 + 6 years. The *yitronot*, deduced from Table 20, represent 6d 5h 223p 60r. We subtract from this number 9h 642p, representing the advance of the first *tekufa*h of Nissan of year 1 AMI on *molad* Nissan year 1 AMI. We find 5d 11h 335p 60r. It represents the delay of the *tekufah* with regard to the *molad* Nissan calculated above. This *tekufah* falls then about Nissan 5. Adding 5d 11h 335p 60r to 1d 15h 754p, we find 7d 11h 335p 60r. The *tekufah* falls on Sabbath at 5h 18.61m a.m. mean time of Jerusalem.

II. NUMERICAL EXAMPLE: THE CALCULATION OF THE MOON'S VISIBILITY ON THURSDAY EVENING, BEGINNING OF FRIDAY, 2 IYAR 4938, 20 M AFTER THE GEOMETRICAL SUNSET IN JERUSALEM

1. Calculation of the *molad* of this month

This problem does not present any difficulty; one finds 4 – 14 – 434.

2. Calculation of the correction for the astronomical mean conjunction

We assume that the astronomical conjunction coincided with the *molad* in Tishri 4507. The time elapsed from this date is 431 years and 8 months or 22 cycles of 19 years and 13 years and 8 months.[14] We find then that the *yitronot* amount to 1026p 41/76, which we round off to 1027p. The astronomical mean conjunction was then about 57m before the *molad* at 4 – 13 – 487. The moment of vision is 6 – 0 – 360, and therefore the span of time between the astronomical mean conjunction and the moment of vision is 1 – 10 – 953.

3. Calculation of the sun's mean longitude at the moment of vision

At the astronomical mean conjunction corresponding to the *molad* of *Beharad*,[15] the sun's mean longitude was 165°; 33' 5". The time elapsed until the mean conjunction of Nissan 4938 represents 259 cycles of 19 years and 16 years and 8 months, and the time elapsed until the moment of vision represents 259 cycles, 16 years, 8 months and 1d 10h 52m 56.67s. This allows calculating the sun's mean longitude at the moment of vision: 35°; 38' 32".

4. Calculation of the sun's apogee

At the astronomical mean conjunction corresponding to *Beharad*, the sun's apogee was at 11°; 36' 36". At the moment of the vision after the span of time defined above, we find that the apogee at the moment of vision was 86°; 45' 12".

5. Calculation of the sun's mean anomaly at the moment of vision

Subtracting the sun's longitude of the apogee from the sun's mean longitude, we find the mean anomaly: 35°; 38' 32" – 86°; 45' 12" = 308°; 53' 20".

6. Calculation of the sun's true longitude

With Table 8 we calculate the quota of the sun's mean anomaly; it is β° = – 1°; 31' 7". The sun's true longitude is then L° = l° – β° = 35°; 38' 32" + 1°; 31' 7" = 37°; 9' 39".

14 The year 4938 is the 17th year of the 260th cycle; it is a leap year.

15 Today, the astronomical mean conjunction precedes the *molad* but at the time of *Beharad* and until 4507, the moment of the mean astronomical conjunction followed the *molad*.

7. Calculation of the sun's true declination

With Table 12 we calculate the sun's declination. We find δ = 13°; 56' 13".

8. Calculation of the sun's set lag

With Table 15 we calculate Δ = 8°; 55' 29". With Table 16 we calculate that it corresponds to 35m 42s. It represents the delay of sunset with regard to 18h.
Until now we had supposed that the sunset was at 18h and that the moment of vision was 6 – 0 – 360. In fact, the corrected moment of vision is 6 – 0 – 360 + 643p = 6 – 0 – 1003.
We correct:

The sun's mean longitude:	35°; 40' 0"	
The sun's apogee:	86°; 45' 12"	
The sun's anomaly:	308°; 54' 48"	
The quota of the mean anomaly:	– 1°; 31' 5"	
The sun's true longitude L°:	37°; 11' 5"	
The sun's true declination δ°:	13°; 56' 42"	(Table 12)
The sun's true right ascension α°:	34°; 49' 43"	(Table 14)
The sun's set lag Δ:	8°; 55' 48"	(Table 15)
The oblique sunset[16] α + Δ:	43°; 45' 31"	

Thus, the point of the equator that has the right ascension of 43°; 45' 31" sets together with the true sun.

9. Calculation of the moon's mean longitude at the moment of vision

We have calculated the moment of vision 35m 42s after 18h 20m or at 18h 55m 42s.
The span of time between the mean astronomical conjunction and the moment of vision was 1d 11h 28m 39s. The time elapsed from the mean astronomical conjunction corresponding to Beharad until the moment of vision was thus 259 cycles of 19 years, 16 years, 8 months, 1 day, 11 hours 28 minutes and 39 seconds. We can then calculate the moon's mean longitude at the moment of vision and find 53°; 41' 16".

16 The oblique sunset + 90° = Ts, the sidereal time or the hour angle of the vernal point at the moment of sunset. Indeed Δ + 90° = H, the hour angle and α + H = Ts, the sidereal time at sunset.

10. Calculation of the moon's anomaly and ascending node

Using Tables 1 through 6 we find in the same manner that the longitude of the moon's mean anomaly is 103°; 41' 15" and the longitude of the moon's mean ascending node is – 182°; 29' 40" or 177°; 30' 20".

11. Calculation of the double elongation

Subtracting the sun's mean longitude from the moon's mean longitude we find the elongation η = 18°; 1' 16" and the double elongation 2η = 36°; 2' 32".

12. Calculation of the quota of the double elongation

With Table 9 we find by interpolation the quota of the double elongation p = 5°; 15' 20"
And the proportion c (helek ha yihouz) c = 4' 3" = 4/60 + 3/3600 = 0.0675.

13. Calculation of the true anomaly

We add the quota of the double elongation to the mean anomaly and find the true anomaly 103°; 41' 15" + 5°; 15' 20" = 108°; 56' 35".

14. Calculation of the quota of the true anomaly

With Table 11 we calculate q = β (2η=0) = 4°; 52' 7"
And s = 2°; 39' 0"
Then c *s = 0.0675 * 2; 39' 0" = 10.7325' = 10' 44".

15. Calculation of the correction β to get the moon's true longitude;

We find β (2η = 36°; 2' 32") = q + c * s = 4°; 52' 7" + 10' 44" = 5°; 2' 51".

16. Calculation of the moon's true longitude

The moon's true longitude L(= l(- β(= 53°; 41' 16" – 5°; 2' 51" = 48°; 38' 25".

17. Calculation of the argument of latitude

We subtract the longitude of the ascending node from the moon's true longitude and we find the argument of latitude: 48°; 38' 25" – 177°; 30' 20" = 231°; 8' 5".

18. Calculation of the first elongation

We subtract the sun's true longitude from the moon's true longitude; it is called the first elongation: 48°; 38' 25" – 37°; 11' 5" = 11°; 27' 20".

19. Calculation of the true moon's latitude

With Table 10 we can calculate the latitude of the moon in function of its argument of latitude; we find – 3°; 53' 24".

20. Calculation of the moon's apparent longitude, the second longitude[17]

The true longitude of the moon is 48°; 38' 25" in Taurus.
Therefore the parallax in longitude is 1°,[18] which must be subtracted from the moon's longitude; we get the longitude of the apparent moon or the second longitude 47°; 38' 25".

21. Calculation of the moon's apparent latitude, the second latitude

The parallax in latitude is 10'. The moon's latitude is negative; therefore the parallax must be added to the moon's latitude to get the apparent moon's latitude – 4°; 3' 24".

22. Calculation of the moon's apparent declination

First step: calculation of the declination of the point of the ecliptic that has the same longitude as the apparent moon. We use Table 12 and find for a longitude of 47°; 7' 53" a declination of + 17°; 7' 53".

17 In my book *Hilkhot Kiddush ha-Hodesh al pi ha-Rambam*, I avoided the use of the questionable table of parallax in longitude and latitude (and the problem of the sign of these components), which was not easy to use in computerized calculation, by a transformation of the ecliptic coordinates of the true moon at the moment of vision into horizontal coordinates. By subtraction of the moon's horizontal parallax of about 1° from the altitude and beholding the azimuth of the true moon, we got the horizontal coordinates of the apparent moon. We calculated then the ecliptic and equatorial coordinates of the apparent moon. The process seems longer but we dealt with computerized calculation. Furthermore, it allowed an elegant resolution of the problem of the parallax.

18 For the calculation of the apparent ecliptic coordinates, Hanover uses Maimonides' table of parallax strictly according to Maimonides' rules: he considers the parallax given in Maimonides' table for Taurus without any interpolation – as he did in his other tables.

Second step: calculation of the supplement of declination corresponding to the moon's latitude of – 4°; 3' 24". We find – 0°; 10' 17", therefore the declination is southern and it is worth 4°; 3' 24" – 0°; 10' 17" = 3°; 53' 7".

23. Calculation of the moon's apparent right ascension

First step: calculation of the right ascension of the point of the ecliptic that has the same longitude as the apparent moon's longitude, i.e. 47°; 38' 25". We use Table 14. We find a right ascension of 45°; 10' 3".

Second step: calculation of the supplement of right ascension corresponding to the moon's latitude of – 4°; 3' 24". We use Table 17 and find + 1°; 11' 20". The right ascension of the apparent moon is 45°; 10' 3" + 1°; 11' 20" = 46°; 21' 23".

24. Calculation of the apparent oblique moonset

The apparent oblique moonset is $\alpha + \Delta$ = 46°; 21' 23" + 8°; 27' 51" = 54°; 49' 14", where α is the right ascension of the apparent moon and Δ is the set lag of the apparent moon found with Table 15 for a declination 3°; 53' 7" and with the longitude of Jerusalem.

25. Calculation of the arc of vision

The arc of vision is the span of time elapsed between sunset and the apparent moon's setting.
The oblique sunset is 43°; 45' 31"; it corresponds to a sidereal time of 133°; 45' 31" at sunset.
The oblique apparent moon's setting is 54°; 49' 14"; it corresponds to a sidereal time of 144°; 49' 14" at the apparent moonset.

The arc of vision is then 54°; 49' 14" – 43°; 45' 31" = 11°; 3' 43".

26. Verification of Maimonides' vision criterion

We must add the arc of vision of 11°; 3' 43" to the first elongation 11°; 27' 20"; we find 22°; 31' 3". The criterion of visibility is satisfied.