Rambam on Calendar

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Introduction

In the "Laws of Sanctification of the Moon", Rambam (TODO: where?) gives algorithmic description of two calendars: fixed ("arithmetic") and observational ("astronomical"). Both calendars are described in the form ready to be implemented, but the reasons for the calculation steps are not always given. Especially for the astronomical calendar, the following questions arise: where do the numbers come from? What are the models - and the formulae resulting from them - that reproduce the numbers? Sometimes Rambam describes the models, so only the formulae need to be reconstructed; sometimes the models are not described, so both the models and the formulae need to be reconstructed.

Goals

- Translate appropriate chapters of Rambam into English. The translation does not have to be literal; literal translations are already available (Yale, Touger). The goal of our translation is to make the text complete and accessible for collaboration by people not proficient enough in Hebrew.
- Reconstruct the models and formulae implied in the text.
- Implement the algorithms.
- Verify consistency of Rambam's numbers.
- Compare Rambam's models with contemporary astronomical models.

History

In 1984, The Rebbe instructed Jews to learn Rambam every day. As a result, in 1991 I encountered calendar chapters of Rambam, decided to reconstruct the models behind the calculations described in them, and discovered mistakes in the text of one of the laws (15:6). The results were published in "Notices of Temimim and Anash", a weekly of the central Lubavicher Yeshiva 770. Some of the readers were appalled that someone dares to correct the text of Rambam! My point was that the text as published contains mistakes that need to be corrected. Indeed, Frenkel edition [Frenkel], that was already published at the time, corrects all of the mistakes I did. In fact, they were already corrected by Hazon Ish in his commentary on Rambam [[HazonIsh]] - but I did not know it then.

In 2005, during a visit to Israel, I discussed the subject with Rabbi Michael Koretz.

In 2008 I acquired a pile of books on the subject and started looking into it; I also experimented with various ways of publishing the work on the web.

In 2009 I coded some of the algorithms to look into the rumors the dates of Birkhat HaHamah that were circulating then.

In 2011 I realized that the work needs to be published before it is finished - so that others could help finish it ;)

Acknowledgements

I want to acknowledge people who contributed to the content of this work - and to the fact of its existence ;) If your name should be on this list but isn't, please forgive me: the omission is not intentional.

Mordechai Goldin - for providing office space and computer equipment when I, as a Yeshiva student, had neither; Ilia Pomansky - for encouraging this work at the early stages, in 1991; my wife Nina - for listening to my wild ideas, for her patience, and for help with math; my daughter Menucha Rochel - for assistance with the translation; Rabbi Michael Koretz - for interesting discussions and help in obtaining texts on the subject; Dr. Michael Partensky - for encouragement and advise; Peter Ofman - for asking questions that prodded me to revive this project in 2011, after years of hiatus; Aron Matskin - for a discussion during his visit on Rosh Chodesh Mar Cheshvan 5772; Rabbi Chaim Prus - for causing me to investigate which number does the year of Creation has - 0 or 1.

Research Questions

Fixed Calendar

New moon from 6:7

Rambam mentiones Nisan conjunction on Sunday, 5 hours and 107 units parts after sunrise. He doesn't give the year, and there seems to be no such year...

RoshHaShono corrections

- are there meaningful names for the corrections?
- are corrections explained by the desire to not have Yom Kippur on Sunday etc.?
- calculate third correction from the maximum length of a year and the first correction
- KH 7:8 says that postponement of RoshHaShonoh is done to align the calendar better with the true molad; analyze the statistics of distances between mean and true molad and RoshHashono.

There is an argument concerning some of the Rosh Hashono delays involving r. Saadia Gaon: https://he.wikipedia.org/wiki/%D7%9E%D7%97%D7%9C%D7%95%D7%A7%D7%AA_%D7%A8%D7%91_%D7%A1%D7%A2%D7%93%D7%99%D7%94_%D7%92%D7%90%D7%95%D7%9F_%D7%95%D7%91%D7%9F_%D7%9E%D7%90%D7%99%D7%A8 Спор о размерах "старого молада", когда он отодвигает Рош ашана на следующий день. По нашей шите от Расага и дальше - 18 часов По шите Аарона Бен Меира - 18 часов и 642/1080 частей часа

make possible calculating the calendar according to the other opinion and compare the results.

Молад года творения человека выходит в пятницу. Это и было Рош а-Шана второго года, ведь тогда принцип ли аду Рош не применялся. Тогда понятней спор Рамбама и Райвада о причине сдвига Рош а-Шана ло аду. Рамбама настаивает, что оно нужно для подсчёта по кибуц эмцаи, а Райвад на него из Талмуда

возмущается. Теоретически можно сделать календарь на время до установления календаря без сдвига Рош а-Шана.

Sun Cycle

Where and when was the Sun created? Compare with Rambam's epoch from the astronomical calendar. Where and how is date of birchat hachamo defined? How would it look according to the other opinion?

Seasons

Rav Ada's tkufos started a week later than Shmuel's! Isn't it readily observable? Analyze the difference in historic periods...

Astronomical Calendar

Epoch

- when was the Sun created?
- introduce "creation" epoch.
- compare calculations based on it and on the Rambam's epoch.
- make possible calculations for a Moment, not just a Day (at least for the sun);

Math.findZero()

Finish and test the code; use two separate lengths (precisions)?

Seasons

calculate true seasons in SeasonsAstronomical; KH 10:7 says that real vernal equinox is approximately two days before the mean one; add a test.

Exactification

Tzikuni gives the algorithm of such reconstruction: add to the remainder as many times 360 as there were full rotations in given time period, and then divide... find the page for exact reference; use it to calculate intervals for Rambam's values of the angular velocities

Angular movement for 29 days

Are Rambam's values reconstructible if value for 29 days is calculated as 3*10-1, not 2*10+9? For any tables other than SunLongitudeMean?

Angular speeds from periods

Convert each year length mentioned in the fixed calendar to angular speed. Angular speed of the moon = 360 / (1/tropical month + 1/solar year). Moon.meanLunarPeriod - what is it called? Tropical?

Distance between the mean and true new moons

KH 5:1-2 says that the distance is no more than a day. Calculate this difference for all months; Rambam's epoch - two days after molad?! (Petya Ofman).

Day of sighting

How to find the day of sighting given a month?

Schedule

Shulchan Aruch

Magen Avraham 428:4 (6): When Pesach falls on Shabbat, so that residents of the Land of Israel read Shmini on the Shabbat following it, there are those that split Tazria and Metzora, and there are those that split Behar and Bechukotai, and if the year is leap, they split Matot and Masai.

Baladi (Yemenite)

instead of Matot and Masai combine Chukat and Balak

Daradaim

(following Rabbi Saadia Gaon): instead of combining Matot and Masai, add to Korach Chukat to 20:21, and next Shabbos read the rest of Chukkat and Balak

3 small aliyot

for 2/5/Shabbos day: look into and implement differences in customs

Проблемы календаря, который устанавливался по свидетельствам наблюдения новой луны.

Отличается от расчитанного:

- основан не на среднем движении солнца и луны, поэтому к молад надо делать поправку, но не путем отодвигания Рош а-шана, а методами последних глав Кидуш а-ходеш
- другой порядок високосных и простых лет
- другой порядок полных и неполных месяцев
- возможно ли рассчитать по Рамбаму начало месяцев по этим принципам и сравнить с завиксированному в традиции датами и днями недели?
- Пример: выход из Египта - 15 день от освящения месяца, четверг
- Год рождения Моше: спор был ли год високосным или простым. Шита Ребе - год был високосным.

3-year cycle

Is anybody orthodox completing Torah cycle in three years? If yes, maybe we should generate that schedule too. Here is the list of Haftarot: https://www.google.com/url?q=https://faculty.biu.ac.il/~ofery/papers/haftarot3.pdf

Solar Theory

Chapter 12, Law 1

It is not clear how Rambam arrived at the values he gives. When value of the movement in one day given by Rambam is multiplied by 29, 100 etc., the result is smaller than that of Rambam. The following table compares printed and calculated values:

days	**value**	**calculated**
n	**v(n)**	**v(1)*n**
1	0°59′8″	0°59′8″
10	9°51′23″	9°51′20″
100	98°33′53″	98°33′20″
1000	265°38′50″	985°33′20″
10000	136°28′20″	9855°33′20″
29	28°35′1″	28°34′52″
354	348°55′15″	348°53′12″

Although the value of the movement of the mean solar longitude in one day given by Almagest III 1 (H209) (which, rounded to seconds, becomes Rambam's value) is bigger, it is not big enough, and Rambam's numbers (for more than 10 days) can not be explained by performing calculations with the long value from Almagest and then rounding the results to the precision of the Rambam's values.

days	**value**	**Almagest**
n	**v(n)**	***n**
1	0°59′8″	0°59′8″
10	9°51′23″	9°51′23″
100	98°33′53″	98°33′49″
1000	265°38′50″	985°38′7″
10000	136°28′20″	9856°21′10″
29	28°35′1″	28°35′
354	348°55′15″	348°54′54″

From the printed values it is possible to reconstruct the value of the movement in mean solar longitude in one day that Rambam used to calculate each of them:

Tzikuni (p. XXX) gives the algorithm of such reconstruction: add to the remainder as many times 360 as there were full rotations in given time period, and then divide. It also gives a value reconstructed from the printed values for 10,000, 1000 and 100 days: 59′8.33″, or 0.9856472 degrees, and the current "scientific" value of 0.9856473 degrees. It seems that origins of the Rambam's value were questioned by his commentators, including "Pirush". Value that can be derived from the tradition that 19 years = 6939 days 16 hours and 595 parts is 0.9856348. This algorithm can be modified to produce an interval of possible values, taking into account precision of the numbers.

Following table compares the printed values with calculations based on the most "precise" reconstructed value - that for 10000 days.

Values of the movement in one day apparently used by Rambam, if rounded to the seconds, give the "official" Rambam's value. Values calculated from the value reconstructed from the printed 10000 days movement, if rounded, produce the values Rambam published - except for 29 days, 354 days, and 10000 days which we use to calculate the exact value that Rambam used! TODO!

Tzikuni quotes Rambam's value for 354 days as 348°55′15″, but calculated value as 348°55′9″, and notes that this "requires a little thought".

Lunar Theory

Chapter 14

Law 1: Two Movements of the Moon

Note: The first is "mean" - because it is corrected by the second, giving "true"? Why is the second "mean"? Because of the effects of the sun?

Note: Wrom what and in which direction are the angles measured?

Law 2: Movement in the Mean Lunar Longitude

days	**value**
n	**v(n)**
1	13°10′35″
10	131°45′50″
100	237°38′23″
1000	216°23′50″
10000	3°58′20″
29	22°6′56″
354	344°26′43″

Discussion

Rambam uses ‘nimzes’ instead of ‘nimzo’ for 10000 days. Also, Rambam says "'ordered' year"; it was rendered as 254 in accordance with Law 12:1.

It is not clear how Rambam arrived at the values he gives. When value of the movement in one day given by Rambam is multiplied by 29, 100 etc., the result is smaller than that of Rambam. The following table compares printed and calculated values:

days	**value**	**calculated**
n	**v(n)**	**v(1)*n**
1	13°10′35″	13°10′35″
10	131°45′50″	131°45′50″
100	237°38′23″	1317°38′20″
1000	216°23′50″	13176°23′20″

days	**value**	**calculated**
n	**v(n)**	**v(1)*n**
10000	3°58′20″	131763°53′20″
29	22°6′56″	382°6′55″
354	344°26′43″	4664°26′30″

Moreover, the value of the movement of the mean lunar longitude in one day given by Almagest IV 3 (H278) (which, rounded to seconds, becomes Rambam's value) is even smaller, so Rambam's numbers can not be explained by performing calculations with the long value from Almagest and then rounding the results.

From the printed values it is possible to reconstruct the value of the movement in mean lunar longitude in one day that Rambam used to calculate each of them:

Following table compares the printed values with calculations based on the most "precise" reconstructed value - that for 10000 days.

Values of the movement in one day apparently used by Rambam, if rounded to the seconds, all give the "official" Rambam's value. Values calculated from the value reconstructed from the printed 10000 days movement, if rounded, produce the values Rambam published - except for 354 days movement, which remains unexplained TODO!

Law 3: Movement in the Mean Lunar Anomaly

days	**value**
n	**v(n)**
1	13°3′54″
10	130°39′
100	226°29′53″
1000	104°58′50″
10000	329°48′20″
29	18°53′4″
354	305°0′13″

Discussion

Rambam says "'ordered' year"; it was rendered as 254 in accordance with see Law 12:1. Also, this value is actually given in Law 4.

It is not clear how Rambam obtained the values he gives. When value of the movement in one day given by Rambam is multiplied by 29, 100 etc., the result is bigger than what Rambam says! The following table compares printed and calculated values:

days	**value**	**calculated**
n	**v(n)**	**v(1)*n**
1	13°3′54″	13°3′54″
10	130°39′	130°39′
100	226°29′53″	1306°30′
1000	104°58′50″	13065°
10000	329°48′20″	130650°
29	18°53′4″	378°53′6″
354	305°0′13″	4625°0′36″

Although the value of the movement of the mean lunar anomaly in one day given by Almagest IV 3 (H278) (which, rounded to seconds, becomes Rambam's value) is smaller, it is not small enough, and Rambam's numbers can not be explained by performing calculations with the long value from Almagest and then rounding the results (TODO: table).

From the printed values it is possible to reconstruct the value of the movement in mean lunar anomaly in one day that Rambam used to calculate each of them:

Following table compares the printed values with calculations based on the most "precise" reconstructed value - that for 10000 days.

Values of the movement in one day apparently used by Rambam, if rounded to the seconds, all give the "official" Rambam's value. Values calculated from the value reconstructed from the printed 10000 days movement, if rounded, produce the values Rambam published - except for 354 days movement, which remains unexplained TODO!

Here, everything is worse than in 14:2 TODO!!!

Law 4: Position of the Moon on the Epoch

Law 5,6: Mean Lunar Longitude at Observation Time

TODO: Compare with 11:9, about Dli... Something is off!

Chapter 15

Law 1: Doubled Distance

Law 2,3: Corrected Mean Anomaly (Elongation (TODO: ?))

Discussion

Rambam does not describe the model behind this correction. Because the models Rambam did describe until now are the same as Almagest's models (including numerical parameters), and because this correction is determined by the (doubled) sun-moon elongation, just like Almagest's "improved" model of the moon ("the crank"), I assume that that model was used to calculate this correction. TODO: describe the model!

TODO: Derive the formula! Make the diagram! TODO: How come the fact that sun and moon move in different plains does not affect this calculation?

It seems that Rambam treats "the crank" as just a calculation device - otherwise, table giving visible anomaly from the corrected anomaly should take into account changes in the earth-moon distance depending on the elongation - and it does not! Maybe that is why he does not describe the model behind this correction. And maybe this is why Rambam reiterates - in Law 2 - that only the observability of the new moon needs to be calculated correctly. TODO: How does Almagest calculate visible anomaly?

Law 4,5,6: True Lunar Longitude

Discussion

Formulae:

$$\tan^{-1}\left(\frac{\sin\alpha}{\cos\alpha+\epsilon}\right)$$

R - radius of the big circle; r - radius of the small circle; $\epsilon = R/r$. A little trigonometry, and we get: visible anomaly = arctg(sin(corrected anomaly)/(cos(corrected anomaly) + e)) and: e = ctg(visible anomaly)*sin(corrected anomaly) - cos(corrected anomaly)

TODO: Make the diagram! Here?

It is clear that values for 150° and 170° are misprinted: they are bigger than the one before them when they should be smaller. Value for 120° is also misprinted, but it is less obvious.

Calculations show that for the precision up to a minute, it is sufficient to know e to up to the second digit after the dot. Below, a column giving the value of e was added to the table. Look at the value of e, and the misprints become obvious: value of e for them is way out of range it is in for the rest of them.

TODO Range of e - graph. Range of possible values for each based on the range of e. This is transcription error: one letter; extra word... Probable correct values.

This is how different sources treat the often misprinted values:

Edition	**120°**	**150°**	**170°**
Vilno	incorrect	incorrect	incorrect
Eshkol	incorrect	incorrect	incorrect
Rambam LaAm	corrected in the notes	incorrect	incorrect
Kapach [a]	incorrect	corrected in the notes	corrected in the notes
Bluming	incorrect	corrected in the notes	corrected in the notes
Frenkel	correct and noted	correct and noted	correct and noted
Keller	not given	not given	not given
Losh [b]	incorrect	incorrect	incorrect

[a] It is not clear how did authoritative Yemenite texts acquire the same misprints as in the ashkenazic editions.

[b] Reprints the text and does not correct any of the misprints - surpising for a textbook on the subject (even introductory). TODO: Link to the scans of the appropriate pages - with the stuff highlighted.

Law 7,8,9:

TODO!!!

Calculate Meton's cycle

Show why 19-years cycle is the best. Calculate optimal distribution of the leap years.

- 1:2 Solar year is ~11 days longer than the lunar (see chapter 6); when discrepancy accumulates to ~30 days, year is made leap. - 4:1-2 Leap year - additional Adar; Pesach (15th of Nisan) must be not before the vernal equinox (Sun enters Aries, see 9:3) and before the next summer solstice.

Moznaim: Based on Sanhedrin 13a-b, the Ramah (cited in Kessef Mish-neh on law 15): "Succos must be after the autumnal equinox"; Rambam doesn't mention this. With vernal equinox on Nissan 15th, autumnal could be on Tishrei 21st, 6 days into Succos. Ohr Sameach: Rambam did say this, printers missed it. Aruch HaShulchan: Rambam holds that that Sanhedrin isn't law; we only care about vernal equinox.

QUESTION: what are the properties of the fixed calendar in this respect (need true seasons)?

- 6:3 Lunar month (between conjunctions) = 29d12h793p. - 6:4 Lunar year (12 lunar months) = 354d8h876p = 354d8h48m40s; Leap lunar year (13 lunar months) = 383d21h589p; Solar year = 365d6h (see also 9:1, 10:6); longer than the lunar year by 10d21h204p. - 6:10 19 year cycle (12+7 leap); because the difference between 19 solar years and the cycle is less than a day: 1h485p. (see 10:1 - with a different year length, the difference is 0)

QUESTION: what other lengths of the cycle have this property?

- 6:11 Leap years: 3,6,8,11,14,17,19.

QUESTION: in what sense is this an optimal correspondence? and for different cycle lengths?

Table of contents of Rambam's Kiddush HaChodesh

General

Chapter 1

Law 1

Month is lunar; year is solar.

Law 2

Solar year is ~11 days longer than the lunar; when discrepancy accumulates to ~30 days, year is made leap.

Law 3

Moon is not seen for ~1 day before and after the conjunction; first night when the Moon is sighted - Rosh Chodesh; next Rosh Chodesh: if it is sighted on the night of the 30th day - 30th; if not - 31st.

Law 4

Short/full month.

Laws 5-8

Court calculates in a manner _resembling_ the calculations of the astronomers.

Chapter 2

Laws 1-10

Court procedure.

Chapter 3

Laws 1-19

Court procedure; messengers.

Chapter 4

Laws 1-2

Leap year - additional Adar; Pesach (15th of Nisan) must in the spring: not before the day of vernal equinox (Sun enters Aries, see 9:3) and before the next summer solstice.

Laws 3-8

Other reasons for leaping the year; (Succos after the autumnal equinox - not mentioned in Rambam.)

Laws 9-17

Court procedure.

Arithmetic calendar

Chapter 5

Laws 1-2

Introduction; discrepancy with observations: -1...+1 day (+1 - very rare).

Law 2

Fixed Rosh Hodesh: sighting of the Moon can be +/- 1 day; +2 - extremely rare.

Law 3

When started.

Laws 4-12

Second day of festivals.

Law 13

Conclusion.

Chapter 6

Law 1

"Molad" - approximate conjunction (Sun. Moon and Earth on the same line).

Law 2

day = 24 hours; 1 hour = 1080 parts.

Law 3

Lunar month (between conjunctions) = 29d12h793p.

Law 4

Lunar year (12 lunar months) = 354d8h876p = 354d8h48m40s; Leap lunar year (13 lunar months) = 383d21h589p; Solar year = 365d6h (see also 9:1, 10:6); longer than the lunar year by 10d21h204p.

Law 5

Lunar month % 7 = 1d12h793p; lunar year % 7 = 4d8h876p; leap year % 7 = 5d21h589p.

Law 7

if molad Nisan - Sunday, 5h107p after sunrise, next month - Iyar: Tuesday night, 5h900p.

Law 8

First conjunction - Tishrei, year #1: Monday, 5h204p (just subtract % from the next one :)) Conjunction of Rosh Hashono of Adam's creation (year #2, see Shmita and Yovel 10:2): Friday, 6h.

Law 9

We do not need the number of days, just the remainders.

Law 10

19 year cycle (12+7 leap); because the difference between 19 solar years and the cycle is less than a day: 1h485p.

Law 11

Leap years: 3,6,8,11,14,17,19.

Law 12

cycle % 7 = 2d16h595p.

Chapter 7

Law 1

Rosh Hashono gets pushed off from Sunday, Wednesday, Friday.

Law 2

Gets pushed off if molad is after noon (Molad Zoken).

Law 3

ADU applies after noon push-off also.

Law 4

Non-leap year, if molad is at night of the 3rd day after 9h204p: push off to Thursday (or the year willbe too long).

Law 5

Year after leap one, Monday, after 5h589p: push to Tuesday.

Law 7

ADU - why?

Chapter 8

Law 1

-> 6.3

Law 2

Month - 29 or 30 days.

Laws 5-6

Same?

Law 7

TODO

Law 8

TODO

Chapter 9

Law 2

1/4 of the year between seasons (91d 7.5h).

Law 3

Nisan (Spring) - Aries; Tammuz - Cancer; Tishrei - Libra; Teves - Cap.? Vernal equinox of year #1 = 7d9h642p before conjunction of Nisan. Notes 5,7 in Moznaim edition. Every year seasons move 30h; in 28 years - in the same place.

Law 5

Vernal equinox, year 4930: midnight, 5th day, 8th of Nisan.

Laws 6-8

Simplified procedure.

Law 7

Real seasons - 2 days before average ones. Note 5: 1st hour of the 4th day of creation; 1st vernal equinox. Autumnal: Wednesday, 3 hours after daybreak, 1d23h before conjunction of Tishrei.

Chapter 10

Law 1

More precise length of a solar year. Moments.

Law 2

Seasons for this year length.

Law 3

Vernal equinox of year #1 - 9h642p before conjunction of Nisan. (Differenbt from 9:3: Rav Ada follows Rabbi Yehoshua - world created in Nisan; Shmuel (9:3) follows Rabbi Eliezer - world created in Tishrei.) Every first year of the 19-year cycle.

Law 4

1/4 of the year between seasons (91d7h519p31m).

Law 5

Simplified procedure.

Law 6

This more precise calculation of seasons was used by Sanhedrin to leap the year because of the spring equinox.

Law 7

Real vernal equinox approximately 2 days before either of these calculations.

Atronomical Calculations

Chapter 11

Laws 1-4

Visibility calculations are deep. Fixed calendar can be appreciated even by school children in 3 or 4 days.

Laws 5-6

Calculations are simplified/approximated to not fluster the inexpreri-enced; result - visibility of the moon - is not affected.

Laws 7-9

360 degrees; 60 minutes, seconds...; order of the 12 constellations.

Laws 10-12

adding/subtracting angles.

Laws 13-14

Velocities are constant. Earth encircled by all the spheres but isn't in the center. Notes 14,15 in Moznaim.

Law 15

Mean and true motion.

Law 16

Epoch.

Law 17

Location: Jerusalem; see Chapter 17.

Chapter 12

Law 1

Movement of the Sun. Moznaim Note 6: calculations may be accurate only on the first day of the month; Note 7. 59′8.33″ Yale, p.99; Neugeb., p. 388ff

Law 2

Movement of the Sun's apogee. Moznaim Note 10: over 800 years, apogee moved ~12 degrees and is in constellation of Cancer. Note 11: position - at 6PM.

Chapter 13

Laws 1-3

Tue position of the Sun.

Law 4

Course correction table.

Laws 5-10

Examples.

Law 11

True seasons.

Chapter 14

Law 1

Moon: epicycle and deferent; movement as seen from Earth. See Moznaim notes!

Law 2

Deferrent table.

Law 3

Epicycle table.

Law 4

Epoch.

Law 5

Time of sighting correction table: ~20 minutes after sunset.

Chapter 15

Laws 1-2

Double elongation and its limits. See Moznaim notes!

Laws 3-5

Course correction table.

Laws 4-7

Parallax correction rules and table.

Laws 8-9

Examples.

Chapter 16

Laws 1-4

Head movement, table and rules.

Law 5

Example.

Laws 6-18

Moon latitude.

Law 19

Example.

Chapter 17

Chapter 18

Chapter 19

Laws of the Sanctification of the Moon: Translation

There is one positive commandment: to calculate, to know, and to establish on which day each month of the year begins. Explanation of this commandment is in these chapters.

Chapter 12

Law 1

The mean rate of movement of the sun in 1 day (that is, 24 hours) is 59′8″. It follows that its movement in 10 days is 9°51′23″. It also follows that its movement in 100 days is 98°33′53″. It also follows that remainder of its movement in 1000 days, after you subtract all [multiples of] 360° (as was explained) is 265°38′50″. It also follows that the remainder of its movement in 10000 days is 136°28′20″.

And in this way you can multiply and calculate its movement for any number [of days] that you want. Similarly, if you want to make known to you values of its movement for 2 days, 3, 4 and so on to 10 - do it. Similarly, if you want for to have known and ready values of its movement for 20 days, 30, 40 and so on to 100 - do it. This is clear and known once you know its movement in 1 day.

And you should have ready and known to you mean movement of the Sun for 29 days and for 354 (which is the number of days in the lunar year when its months are "regular" (TODO link), and it is called "regular year"). The reason is: if you have those movement values ready, this calculations of the visibility of the moon will be easy, because there are 29 complete days from the night of observation to the night of observation of the following month, and so it is every month: no less than 29 days and no more. Since our sole desire in all those calculations is exclusively to determine visibility [of the moon]. And between the night of sighting of this month and night of sighting of the same month next year there is either a regular year or a year and 1 day; and the same every year. Mean movement of the Sun in 29 days is 28°35′1″. Its movement in a regular year is 348°55′15″.

Law 2

There is a point on the Sun's orbit (and on orbits of the other 7 planets) such that when the planet is there it is highest above Earth. This point

of the Sun's orbit (and so for other planets, except for the moon) rotates with constant speed. Its movement every 70 years is approximately 1°. This point is called *Sun's apogee*. Its movement in 10 days is one and a half seconds, i.e. 0°0′1″30‴. It follows that its movement in 100 days is 0°0′15″. Its movement in 1000 days is 0°2′30″. Its movement in 10000 days is 0°25′. It also follows that its movement in 29 days is 0°0′4″ and a bit more; and its movement in a regular year is 0°0′53″.

We already said that the epoch that our calculations start from is beginning of the night of the fifth day that is 3rd of Nisan of the year 4938 from the Creation. Position of the Sun in its mean movement at the epoch was 7°3′32″ in the constellation of Ram (Tele). Position of the Sun's apogee at the epoch was 26°45′8″ in the constellation of Twins.

Glossary

Astronomical terms

Sun's apogee	Point on the orbit of the Sun where it is highest above the Earth.
mean lunar anomaly (אמצע המסלול)	Mean angular coordinate of the Moon on its epicicle.

Bibliography

Laws of Sanctification of the Moon by Rambam

[Vilno] Rambam. *Mishne Torah*. Widow and Brothers Romm.

[Rambam LaAm] Rambam. *Mishne Torah*. Rambam LaAm.

[Eshkol] Rambam. *Mishne Torah*. Eshkol. 1987.

[Kapach] Rambam. *Mishne Torah*. Rabbi. Kapach.

[Frenkel] Rambam. *Mishne Torah*. Rabbi. Frenkel.

[Bluming] Rambam. *Mishne Torah*. Rambam HaAruch. Rabbi. Y Bluming. 2005.

[Yale] Rambam. Solomon Gandz. Julian Obermann. *Mishne Torah*. *Code of Maimonides, Book 3, Treatise 8: Sanctification of the New Moon (Yale Judaica Series, Vol. 11)*. Yale. 1967.

[Touger] Rambam. *Mishne Torah*. Rabbi. Touger.

[HazonIsh] Hazon Ish.

Jewish Writings on Calendar

[Losh] *Sefer HaTchunah LeMatchil*. Yosef Yitzchok Losh. 1988.

[Keller] *Tchunat HaShamaim*. Yosef Yitzchok Keller. 1988.

[Glitzenshtein] *Kidush HaChodesh LeHaRambam*. Menachem Mendel Glitzenshtein. 1993.

[Tzikuni] *הזון שמים (Hazon Shamaim)*. Eitan Tzikuni. 2001.

Hazon Ish and the sine tables. http://www.biu.ac.il/JH/Parasha/pekudey/lev.html.

Greeks on Astronomy

[Neugebauer] *The Exact Sciences in Antiquity*. Otto Neugebauer. 2nd. Dover Publications. 1969. http://isbn.nu/0486223329.

Astronomy and History Selected Essays. Otto Neugebauer. Springer. August 8, 1983. http://isbn.nu/0387908447.

[Crowe] *Theories of the World from Antiquity to the Copernican Revolution*. Michael J. Crowe. 2nd. Dover Publications. 2001. http://isbn.nu/0486414442.

[Evans] *The History & Practice of Ancient Astronomy*. James Evans. Oxford University Press. 1998. http://isbn.nu/0195095391.

[Thurston] *Early Astronomy*. Hugh Thurston. Springer Verlag. 1996. http://isbn.nu/0387948228.

[Almagest] *Ptolemy's Almagest*. G. J. Toomer. Princeton University Press. 1998. http://isbn.nu/0691002606.

[Campanus] *Campanus of Novara & Medieval Planetary Theory*. G. J. Toomer, Jr and Francis S. Benjamin. University of Wisconsin Press. 1972. http://isbn.nu/029905960X.

Ancient Planetary Model Animations. http://people.sc.fsu.edu/~dduke/models.

A Modern Almagest: An updated version of Ptolemy's Almagest. http://far-side.ph.utexas.edu/Books/Syntaxis/Syntaxis.html.

Summary of Ptolemaic Astronomy. http://www.clas.ufl.edu/users/ufhatch/HIS-SCI-STUDY-GUIDE/0034_summaryPtolemiacAstron.html.

Contemporary Models

[Meeus] *Astronomical Algorithms*. Jean Meeus. 2nd. Willmann-Bell. 1998. http://isbn.nu/0943396611.

[Montenbruck] *Astronomy on the Personal Computer*. Oliver Montenbruck and Thomas Pfleger. 4th. Springer Verlag. 2000. http://isbn.nu/3540672214.

[Dershowitz] *Calendrical Calculations*. Nachum Dershowitz and Edward M. Reingold. 3rd. Cambridge University Press. 2008. http://isbn.nu/0521702386.

[Dermott] *Solar System Dynamics*. S. F. Dermott and Carl D. Murray. Cambridge University Press. 2000. http://isbn.nu/0521575974.

How to compute planetary positions. http://stjarnhimlen.se/comp/ppcomp.html.

Sky View. http://www.sky-view.co.il/.

Israeli New Moon Society. https://sites.google.com/site/moonsoc/.

EarthTools. http://www.earthtools.org/webservices.htm#usage.

NOAA Solar Calculator. http://www.esrl.noaa.gov/gmd/grad/solcalc/.

Naval Oceanography Portal. http://aa.usno.navy.mil/data/index.php.

Zmanim. http://www.myzmanim.com/search.aspx.

MikvahCalendar. https://www.mikvahcalendar.com/.

On Jewish Calendar

Understanding the Jewish Calendar. Nathan Bushwick. Moznaim. February 1, 1989. http://isbn.nu/0940118173.

The Hebrew Calendar. Dr. Irv Bromberg. University of Toronto, Canada. http://www.sym454.org/hebrew.

[Feldman] W. M. Feldman. *Rabbinical Mathematics and Astronomy*. Judaic Studies Library; No. Shp4. Intellectbooks. January 1, 1931. 3. http://isbn.nu/0872030261.

Belenkiy. http://u.cs.biu.ac.il/~belenka/calendar.html.

Bromberg. http://individual.utoronto.ca/kalendis/.

Remy Landau. *Hebrew Calendar Science and Myths*. http://hebrewcalendar.tripod.com/.

Sacha Stern. *Calendar and Community: A History of the Jewish Calendar, 2nd Century BCE to 10th Century CE*.

The Reality of Epicycles and Eccentrics Denied. http://homepages.wmich.edu/~mcgrew/maimonides.htm.