COMMENTS

J. Jean Ajdler, Reaction to Ariel Cohen's Article, "How Maimonides Chose His Epoch. Clarifications Regarding the Astronomical Calculations in the Sanctification of the New Moon." *B.D.D.* 26, pp. 69-80 and English Abstract on p. 72.

In this reaction we will restrict ourselves to Maimonides' astronomical calculations *stricto sensu*, to the exclusion of paragraph 4 related to curiosities of the Jewish calendar, unrelated to the main topic of the article.

1.

Cohen's statement that the astronomical chapters of *Hilkhot Kiddush ha-Hodesh* were also intended for Muslim and Samaritan scholars is not likely at all. *Hilkhot Kiddush ha-Hodesh* is an integral part of the *Hibbur,* Maimonides' only work written in Hebrew. This particularity was not unconsidered or thoughtless; Maimonides was well conscious of the importance of this work for Judaism, indeed he hoped that it would be accepted as the work summarizing the whole oral law and would follow directly the Torah; hence its name *Mishneh Torah*. Even the astronomical part of it was certainly intended for Jewish scholars and certainly not for non-Jews. As he explains in 19:16, the last paragraph of *Hilkhot Kiddush ha-Hodesh*, he wanted to expound all the aspects of the law including the calculations of the visibility of the new moon. So the [Jewish] students [of the law] would not miss this particular branch and would not need to ramble about in other books. The aim of the inclusion of these calculations in his great treatise of the law is thus clearly pointed out. The book and its astronomical chapters represent a summary of the oral law and are aimed at Jewish scholars. How could gentile scholars have access to it?

It is the result of pure chance that the new moon of Nissan of the year 1178, when he wrote the last chapters, was also the end of the fast of Ramadan. Cohen's statement is not substantiated by any other element than this coincidence of the epoch with the beginning of the Eid-el-Fitr.

2.

Cohen's statement that Maimonides noted that he knew the work of al-Battani is incorrect. The name of al-Battani is not mentioned in the works of Maimonides, by contrast with Ptolemy and his Almagest. Maimonides mentioned also the Sevilian

astronomer ibn Aflah and the astronomer Abu Bekr ibn Alzaig (Guide II:9). R. Obadia ben David (14th century) was the first to point out Maimonides' dependence on al-Battani.[1]

3. The mean conjunction of Nissan 4938 according to Maimonides

Cohen is unfortunately unclear, imprecise and unsubstantiated. In his paper he does not indicate the moment of the epoch. He speaks[2] about Maimonides' mean conjunction which happened at 8h 18m 42s Jewish time preceding the *molad* by 1h 17m without specifying what he is speaking about. In fact if we add these two times, transformed in Jewish time, we get 8h 336.60 hal + 1h 306 hal = 9h 642.60 hal which must correspond to the *molad* of Nissan 1 AMI, Nissan of the first year of the era of Beharad: 2 – 5 – 204[3] + 2 – 4 – 438[4] = 4 – 9 – 642.[5]

Apparently the meaning of Cohen's statement is that at the time of Nissan AMI, the *molad* was 4 – 9 – 642, but Maimonides' mean conjunction was 1h 306 hal before, at 4 – 8 – 336.

Where did Cohen find the figure 1h 306 hal for this difference?

Apparently he found it in the following way:

The epoch

Cohen doesn't give any information about Maimonides' epoch in his article. On his website I found that the epoch is JD 2151403.152083. It corresponds to Wednesday 22 March 1178, 3h 39m p.m. GMT. It corresponds exactly to 6 h p.m. JMT.[6]

Note already that the use of local mean time is anachronistic as the notion of modern mean time, as we understand it today, was introduced only in 1672 when Flamsteed, the Astronomer Royal, wrote his famous dissertation on the equation of time.

The astronomical mean conjunction

According to Maimonides' data we have:

Mean movement of the sun per day: 0°; 59' 08.33" = 0.985647222°/d

1 See *Hilkhot Kiddush ha-Hodesh* 12:1.
2 p. 72 bottom line.
3 The epoch of Beharad.
4 The residue of 6 months.
5 The *molad* of Nissan of the first year of the era AMI.
6 Jerusalem Mean Time.

Mean movement of the moon per day: 13°; 10' 35.03" = 13.17639722°/d
Relative movement: 12.19075°/d
Jewish month: 29 – 12 – 793 = 29.530594136 d
Astronomical mean month: 360 / 12.19075 = 29.530586715d
Jewish month – Astronomical mean month = 7.42 10^-6 d. This result is dubious because the angular velocities of sun and moon were calculated from the values given by Maimonides for 10,000 days. These values probably do not reflect the true values of al-Battani.
At the epoch:
Mean sun: 7.0589°
Mean moon: 31.2453°
Mean Elongation: 24.1864°
The mean conjunction occurred 24.1864 / 12.19075 = 1.9839960625 d before the epoch i.e. (2d – 414.82 hal) before the epoch. If the epoch was 5 – 0 – 0, then the mean conjunction was 3 – 0 – 414.82.
Now the *molad* of Nissan 4938 was 3 – 1 – 721. It followed the mean conjunction by (3 – 1 – 721) – (3 – 0 – 415) = 1h 306 hal.
It is even likely that Cohen found all these elements at the bottom of p. 328 of Otto Neugebauer's paper: "The Astronomy of Maimonides," HUCA, Cincinnati, 1949.[7]

On his website Cohen writes that this difference is equal to the difference between Ptolemy's data in the Almagest and the *molad* + 33 m.
The *molad* is in fact the mean conjunction of the Almagest + 850 hal.[8] This difference includes 22m = 396 hal for the difference of longitude of 5.5° between Jerusalem and Alexandria. The remaining difference of 850 – 396 = 454 hal = 25.2 m would correspond to an additional difference introduced, according to Borenstein, in order to round off the molad to 6 – 14 – 0 Veyad for Tishri 1 AM2[9] or 2 AM1.[10]

Thus 1h 306 hal – 850 hal = 536 hal = 29.78 m ~ 30m. I ignore the origin of the figure 33m; it must be a mistake. Now in the present paper Cohen writes that the difference of 1h 306 hal between the *molad* and Maimonides' mean conjunction is 33m greater than the difference existing between Ptolemy's data in the Almagest, adapted to Jerusalem and the *molad*. This statement is incorrect because the difference between the data of the Almagest adapted to Jerusalem and the *molad* is

7 However, Cohen does not refer to this paper.
8 In BDD 26, p. 66, an unfortunate misprint happened: The *molad* is equal to the data of Ptolemy + 850 hal and not –.
9 The *molad* of Tishri of the first year of the era AM2 (Veyad).
10 The *molad* of Tishri of the second year of the era AM1 (Beharad).

not more 850 hal but 850 – 396 = 454 hal and adding 33m + 1 hal to it we get 1049 hal < 1h 306 hal.

Now it appears that these calculations are blemished by different mistakes. Furthermore Prof. Cohen seems unaware of the different improvements that were recently reached in the understanding of Maimonides. These achievements were expounded in the article "The Equation of Time in Ancient Jewish Astronomy."[11] These main achievements are the following:

- The ancients did not calibrate their mean time i.e. the time of their tables, as we do.
- Mean Time of al-Battani + 16.44m = modern mean time.
- Mean Time of Almagest + 17.57m = modern mean time.
- Maimonides and the ancients probably did not differentiate between Almagest Mean Time and al-Battani Mean Time.
- The *molad* is in all likelihood estimated in the mean time of the Almagest as it is certainly derived from it.
- It makes no sense and it would be anachronistic to fix Maimonides' epoch at 6 p.m. Jerusalem Mean Time (Neugebauer before he studied the problem of the equation of time, Ariel Cohen), at 6h 20m p.m. Jerusalem Mean Time (Hanover, Wiesenberg, Ajdler (1996)) as the modern mean time, introduced by Flamsteed in about 1672, was a concept unknown to Maimonides.
- Maimonides' epoch corresponds to the beginning of the night, 20m after apparent sunset i.e. after the apparent (taking into account the refraction)[12] disappearing of the upper limb of the sun on the evening of Wednesday 22 March 1178. It was 6h 34m true time, 6h 22m al-Battani Jerusalem Mean Time and 6h 38.5m Jerusalem modern mean time. In this way the epoch is the exact moment of vision and therefore it makes sense that the addition or the subtraction of an integer number of days[13] leads us each time to a moment of vision. It appears also that even if Maimonides never spoke about the equation of time and neglected it in his visibility calculations, he mastered this concept and took it into consideration when he fixed his epoch and the corresponding radices from al-Battani's tables.

11 BDD 16, pp. 5-56. Although it is my paper, I want to thank Ya'akov Loewinger for these improvements. Indeed we groped together in the dark, trying to understand al-Battani; we each corrected the other's mistakes and we would probably not have reached the results independently.

12 See BDD 16, p. 24, note 71, where I give a justification to this assertion

13 With a correction taking into account the inequality of the length of the days in function of the longitude of the sun.

We can now go back to the preceding calculations and correct them. All the calculations will be performed in al-Battani Jerusalem Mean Time and we will accept the approximation that the *molad* is also given in the same time. The epoch was thus at 6h 22m p.m. aBJMT.
The epoch was 5 – 0 – 396; we subtract (2d – 414.82 hal) and we get 3 – 0 – 811 for the mean conjunction.
The *molad* preceded the mean conjunction by (3 – 1 – 721) – (3 – 0 – 811) = 990 hal = 55 m.

Now we must examine the truth of Cohen's statement at the top of page 73 according to which the length of the mean solar year and the mean synodical month are constant; therefore according to Cohen, the span of time between Maimonides' mean conjunction and the *molad* is a constant, whether in 2011, in 1178 or at Beharad in –3760.

This statement can be demonstrated elegantly by the examination of the conjunction table of al-Battani.[14]

We note in this table:
990y 22d 6' 23"
1490y 21d 10' 41"
Thus in 500 Egyptian years the conjunction shifts with 55' 42" corresponding to a fraction of one day of 0.928333333333 d.
Thus 182500 d – 0.928333333 d = 6180 lunations
al-Battani lunation is 29.5305941209 d
Jewish lunation is 29.530594135804 d
$\Delta = 1.49\ 10^{-8}$d. The difference accumulated during 61069 months[15] is only 1.31 minutes. It is insignificant.

In fact, I note also that in the sygyzy table of the Almagest,[16] we have the same shift 55' 42" in 500 Egyptian years. There is thus no difference between the bases of both tables and therefore the distance between the conjunctions given by both tables must remain constant.

The statement of Professor Cohen is thus correct.[17]

14 Nallino, vol 2, p. 23.
15 From Beharad until the the *molad* of Nissan 4938.
16 Almagest, Toomer VI: 2, pp. 278-280.
17 But the reason invoked is unclear. The only reason is that the length of the synodical lunation is fundamentally the same in both tables, in that of Ptolemy and that of al-Battani.

4. Finally, Professor Cohen examines on p. 73 the problem of the *tekufah*

The mean longitude of the sun at the epoch is 7.0589°, the angular velocity of the sun is 0.985647222°/d so that the mean *tekufah* was 7.1617 d before the epoch, thus on March 15, at 14h 29m Jerusalem al-Battani Mean Time.

The *tekufah* of Samuel (chap. 9) was on Sunday March 26 1178 at 0h al-Battani Jerusalem Mean Time.[18] The *tekufah* of R. Adda (chap. 10) was on Friday March 17 1178 at 7h 28m al-Battani Jerusalem Mean Time.[19]

The important differences are the result of the accumulated differences of the length of the tropical year. Cohen's remark that the *tekufah* given in chap. 10, thus that of R. Adda, corresponds to a longitude of 19° east to Jerusalem is incomprehensible. It could only justify a difference of 1h 16m; we have here a difference of about 1.75 days.

5. Summary table

The following table clarifies the subject and the methodology explained in more detail, in BDD 16, but without a summary table.
From Maimonides' radices, we find that the mean elongation at the epoch was 24°; 11' 06".
The angular velocity of the elongation is 12.1907469366°/h.
The mean conjunction occurred 2d – 23 m before the epoch.
From al-Battani book 2, pp. 84-86, we deduce the moment of the mean conjunction.
Hence the time of the epoch.
At the moment of the epoch, the true solar longitude was 9°; 00' 17".
The geometrical sunset is at 6h 09m true time and the apparent sunset is at 6h 14m true time.
The *aequatio nychtemeron* (equation of the days) is 2°; 57' or 11.8m, subtractive from true time to mean time. The modern equation of time is + 4.5m with T = Tm – E.

	Ar-Raqqah	Jerusalem		
	aBaRMT[20]	aBJMT[21]	True Time	JMT[22]
Molad Monday March 20, 1178		7h 40m		
Mean Conjunction	7h 12m	6h 45m		
Epoch Wednesday March 22, 1178	6h 49m	6h 22m	6h 34m	6h 38.5m
Geometrical sunset			6h 09m	
Apparent sunset			6h 14m	

18 Assimilating again Almagest mean time and al-Battani mean time.
19 Assimilating again Almagest mean time and al-Battani mean time.
20 al-Battani ar-Raqqah Mean Time.
21 Al-Battani Jerusalem Mean Time.
22 Modern Jerusalem Mean Time = GMT + 2h 21m.

Maimonides' epoch in *Hilkhot Kiddush ha-Hodesh*

J. Jean Ajdler: A reaction to Professor Cohen's answer (Hebrew section, pp. 155-161).

I am afraid that Professor Cohen misses the point.

3. I proved by the comparison of Maimonides' radices and the table of al-Battani's mean conjunctions that Maimonides' epoch was 6h 49m p.m. aBaRMT, al-Battani ar-Raqqah mean time. It corresponds to 6h 22m aBJMT or 6h 34m Jerusalem True Time. On this day the geometrical sunset was at 6h 09m True Time and apparent sunset 6h 14m True Time.

Maimonides accepts rough approximations in the visibility calculations and in the calculation of the coordinates of the sun and moon at the moment of the visibility. But the calculation of the epoch and the radices was made with the greatest precision, including the taking into account of the equation of the days or *aequatio nychtemeron* i.e. the equation of time of the ancients.

The epoch is defined in HKH[1] 11:16 and HKH 12:2 as being the beginning of the night but in HKH 14:6 he defines the moment of vision as **being about 20m after sunset**. This is also his definition of the halakhic beginning of the night in *Hilkhot Terumot* 7:2. From the end of chap. 12 we can deduce that the epoch is a moment of vision.

3b. All the calculations of Cohen are useless and incorrect. The difference between the *molad* and Maimonides' conjunction is 55m. Of course if the epoch is put by Cohen at 6 p.m. instead of 6h 22m the difference is indeed 1h 17m. But the difference between the *molad* and Ptolemy's conjunction is 850 hal = 47.22m and not 44m (see Slonimsky, Bornstein and Jaffe).

3d. See 3 above. From the table of Ptolemy's conjunction we know that the mean conjunction was at 7h 12m aBaRMT or 6h 45m aBJMT. We know further that the epoch was 6h 49m p.m. aBaRMT or 6h 22m aBJMT. See Neugebauer p. 343 if he inspires more confidence. By the way, it is here that Neugebauer made his mistake: he placed the epoch 6h 50m (it was at this moment that the coincidence between Maimonides' radices and al-Battani's coordinates was optimal) after mean noon in ar-Raqqah or 6h 22m aBJMT = 6h 38.5m JMT and 6h34m True Time; but he wrote on p. 342 that the epoch was at 0h (Jewish Time).

1 HKH = *Hilkhot Kiddush ha-Hodesh.*

As the geometrical sunset was at 6h 09m True Time and the apparent sunset was at 6h 14m True Time I concluded that the epoch was 20m after apparent sunset. We must conclude that Maimonides calculated his epoch and radices with the highest precision like a professional astronomer. However, in his simplified algorithm he accepted rough approximations. He also neglected the fact that the epoch is at 6h 22m aBJMT instead of 6h in the calculation of the inequalities of the length of the days.

5. Cohen writes that HKH 10 refers to the situation at the time of Beharad and not in 1178.

This is a new invention. Maimonides writes clearly in HKH 10:7 that he refers to his time. There is never reference to the time of creation; that is sheer invention. Here is an additional proof:

רמב"ם הלכות קידוש החודש פרק ט הלכה ו. אם תרצה לידע בכמה יום בחדש תהיה תקופת ניסן של שנה זו, תדע תחלה באיזה יום מימי השבוע תהיה ובאיזה יום יקבע ניסן של שנה זו וכמה שנים גמורים עברו מן המחזור, ותקח לכל שנה אחד עשר יום ותוסיף על סכום הימים שבעה ימים בזמנים אלו, והשלך הכל שלשים שלשים והנשאר פחות משלשים תתחיל למנותו מראש חדש ניסן, אם יגיע ליום התקופה מוטב ואם לאו הוסיף יום או שני ימים או שלשה ימים על המנין עד שיגיע ליום התקופה, ואם תהיה השנה מעוברת תתחיל למנות מראש חדש אדר שני וליום שיגיע החשבון באותו היום מן החדש תהיה התקופה.

The addition of **7 days** is only correct in the days of Maimonides! (see Y. Loewinger, *Al ha-Sheminit*, Tel Aviv 5746, pp. 104-109).