

Molad Zaqen and Islamic Scientific Innovation¹

By: ARI STORCH

Introduction

The contemporary Hebrew calendar is a lunar one that sets the first day of the year based on the *molad*, the time of a lunar conjunction.² A lunar conjunction describes a distinct position of the moon, relative to the earth and the sun. The date of the *molad* of Tishrei, the seventh Hebrew month, is declared the first day of the year, Rosh Hashanah; however, should this occur on a Sunday, Wednesday, or Friday then the next day is chosen. One exception, however, is at the occurrence of a *molad zaqen*, when the *molad* occurs after midday; in this case, the following day is declared Rosh Hashanah. Historical evidence strongly suggests that this exception was not implemented until the ninth century, leaving the question of why it was instated in the post-Talmudic era. Scientific advancements of that time period in Islamic lands may answer this question.

The Molad

As mentioned above, the *molad* is a lunar conjunction. As the moon orbits earth it reflects the light of the sun. The apparent shape of the moon depends on its position relative to the sun. A lunar conjunction is defined as when the moon is aligned with the earth and sun in such a way that all its light is reflected toward the sun rendering it invisible to those on earth. It is from this point that its orbit will begin to allow it to reflect light earthwards slowly causing it to be seen as a crescent, half moon, gibbous, and then full moon.

In contemporary time, the date of the occurrence of the *molad* of Tishrei is generally used to declare Rosh Hashanah's observance. The moon does not complete its orbit in the exact duration of time each

¹ I thank Sender Epstein for his invaluable insights and helpful comments.

² This concept will find further elucidation in the main body of this article.

Ari Storch attended Yeshivat Kerem B'Yavneh and Ner Israel of Baltimore. He is currently the rabbi of Congregation Ohr Simcha of Baltimore and is the author of *Tiferet Aryeh* on *Zevachim* and *The Secrets of the Stars*.

month, leaving debate as to the definition of the word “*molad*” within Talmudic texts. R. Zerahiah Halevi (c. 1125 – c. 1186) maintains that “*molad*” is the actual time of conjunction,³ whereas Rambam (b. 1135 – d. 1204) concludes that it is the average time of a conjunction that is utilized.⁴ The much earlier liturgical poetry of R. Elazar b. Qilir (c. 570 – c. 640),⁵ citations of Saadiah Gaon (c. 882 – d. 942),⁶ and the writings of Ravad (b. 1125 – d. 1198)⁷ all side with R. Zerahiah Halevi.

Reasons for *Molad Zaqen*

One exception to declaring Rosh Hashanah on the date of the *molad* is called *molad zaqen*. The Talmudic passage credited as the source of *molad zaqen* is a fairly obscure one. In it, Shmuel states that he has the wisdom to set an accurate calendar, thereby eradicating the need for testimony or *beit din*. Abba, R. Simlai’s father, challenges Shmuel’s assertion by questioning whether Shmuel truly understands the thus-far baffling credo “If the *molad* is before midday or if the *molad* is after midday.”⁸ Shmuel responds that he cannot. Abba, R. Simlai’s father, thus proclaims that Shmuel may also be unfamiliar with other laws pertaining to the calendar, rendering Shmuel’s calendar unusable. R. Zeira then clarifies this ambiguous passage: If the *molad* was prior to midday then the new moon could be sighted close to sunset. But, if the *molad* occurred after midday then the moon cannot be sighted prior to sunset. R. Ashi explains that the practical application of this ruling is “to impugn witnesses.”⁹

³ *Ha-Ma’or Ha-Qatan, Rosh Ha-Shanah* 20b. In R. Zerahiah’s words, “ומולד הלבנה, “הוא דבוק הלבנה וכו’.”

⁴ *Hilkebot Qidush Ha-Hodesh* 6:1. This is in contrast to *Peirush Ha-Rambam, Rosh Ha-Shanah* 20b where “*molad*” is taken to mean actual conjunction. There have been doubts as to the authenticity of this commentary and even if Rambam is the author, it has been suggested that it was written in his youth. See <<http://www.shaalvim.co.il/torah/maayan-article.asp?id=349>>. *Meiri* cites the opinion of *Peirush Ha-Rambam* as seen in *Beit Ha-Bebirah, Rosh Ha-Shanah* 20b.

⁵ *Yotzer Parsbat Ha-Hodesh*.

⁶ *Rashi, Rosh Ha-Shanah* 20b. *Rashi* clearly attributes to Saadiah Gaon that six hours after a conjunction the moon is definitely visible. Such certainty could not be attributed to an average conjunction because, by definition, the average will not yield definitive results.

⁷ *Ravad Katuv Sham, Rosh Ha-Shanah* 20b.

⁸ As the Talmud states, “נוולד קודם חצות או נוולד אחר חצות.”

⁹ *Rosh Ha-Shanah* 20b.

While Rabbenu Ḥananel (c. 990 – d. 1053) suggests that this passage is the source of *molad zaqen*,¹⁰ it is R. Zeraḥiah Halevi who later elucidates that the human eye is incapable of sighting the moon prior to sunset until twenty-four hours after the *molad*. Since the sages did not want to declare Rosh Hashanah on a date when it was impossible for the moon to be seen anywhere in the world, they invoke the rule of *molad zaqen* and proclaim the following day Rosh Hashanah.

R. Zeraḥiah further explains that since the new moon cannot be seen until twenty-four hours after the *molad*¹¹— which is set at Jerusalem time—and Jerusalem is eighteen hours ahead of the farthest point east, the rule of *molad zaqen* guarantees that at some point over the course of the day of the *molad* the moon will be visible somewhere on earth. Thus, if the *molad* occurs prior to midday, there are more than six hours left until sunset in Jerusalem and more than twenty-four hours left until sunset, of that same day, at that easternmost point, allowing the moon to be seen prior to sunset on the day of the *molad*. However, if the *molad* is after midday, there are fewer than six hours until sunset in Jerusalem and fewer than twenty-four hours until sunset at that easternmost point. In this case, the moon cannot be sighted anywhere in the world on the date of the *molad* and Rosh Hashanah must, instead, be on the following day. This, says R. Zeraḥiah, is the underlying idea expressed in the Talmudic passage.¹²

Conflicting Opinions

R. Zeraḥiah's approach is not unanimous and, in fact, found strong opposition. Ravad states that R. Zeraḥiah plagiarized the works of *Kuḏari* and R. Avaraham b. Ḥiyya, albeit without proper understanding of the originals. Additionally, Ravad contends that these original sources, too, misinterpreted the Talmud due to their desire to infuse into the Talmud their personal scientific understandings. Instead, Ravad cites R. Yitzḥak b. Barukh and counters that the moon is visible only six hours after conjunction and the focus of the Talmud is on those in Jerusalem. The concept of *molad zaqen* has no place in this passage according to this opinion;

¹⁰ Rabbenu Ḥananel, *Rosh Ha-Shanah* 20b.

¹¹ In R. Zeraḥiah's words, "וזה יתרון מהלך הלבנה על החמה בכ"ד שעות." This is echoed by Rambam *Hilkhot Qidush Ha-Hodesh* 1:3 where Rambam states a value of approximately twenty-four hours. Although in *Peirush Ha-Rambam, Rosh Hashanah* 20b the value of six hours is used. See footnote 4.

¹² *Ha-Ma'or Ha-Qatan, Rosh Ha-Shanah* 20b.

rather, the text is understood in its simple form. Should witnesses claim they witnessed the moon within six hours after conjunction they are deemed false witnesses as they have proclaimed to have seen an impossible sight.¹³ It seems that Ravad understands that Shmuel's unawareness of the astronomical basis of this rule brought into question the reliability of the astronomical information upon which his proposed calendar was based. Abba, R. Simlai's father, thus declared that there may be other astronomical errors contained in Shmuel's calendar.

This belief that the moon could be sighted six hours after the *molad* was far more pervasive than that of R. Zerahiah's twenty-four. This belief is also expressed in *Midrash Tanhuma*,¹⁴ *Talmud Yerushalmi*,¹⁵ *Pesiqta de-Rav Kahana*,¹⁶ *Midrash Hagadol*,¹⁷ R. Elazar b. Qilir's writings,¹⁸ and citations of Saadiah Gaon.¹⁹ Perhaps the concept of *molad zaqen* did not exist in the time of these sages. Or, perhaps it did, and these authorities ascribed its purpose to the sages' reluctance to establish Rosh Hashanah on a day that the moon was not visible in Jerusalem. Should the *molad* have occurred prior to midday then the moon could theoretically be sighted prior to sunset in Jerusalem itself. If not, then it would not be visible until after sunset. When establishing a formalized calendar this concept may have been perpetuated by the creation of *molad zaqen*. According to this approach there is no Talmudic source for *molad zaqen*.²⁰ This is not unusual, though little information about the calendar and its rules is found in the Talmud.²¹

The belief that the moon can be sighted six hours after a conjunction is difficult to reconcile with contemporary observation if the term *molad* is assumed to refer to the actual lunar conjunction, as is the opinion of R. Elazar b. Qilir, Saadiah Gaon, R. Zerahiah Halevi, and Ravad.²² However,

¹³ *Ravad Katuv Sham, Rosh Ha-Shanah* 20b.

¹⁴ *Midrash Tanhuma, Bo* 10 (Buber).

¹⁵ *Yerushalmi, Rosh Ha-Shanah* 14a.

¹⁶ *Pesiqta de-Rav Kahana, Ha-Hodesh* 54b (Buber).

¹⁷ *Midrash Ha-Gadol, Bo* 12:2.

¹⁸ *Yotzer Parsbat Ha-Hodesh*.

¹⁹ Rashi, *Rosh Ha-Shanah* 20b.

²⁰ As will be discussed later, *molad zaqen* did exist in the times of Saadiah Gaon. Additionally, it seems he understood the passage from *Rosh Ha-Shanah* to be referring to it. See footnote 31.

²¹ R. Yaaqov of Marvege asserted that when he asked the heavens like whom the passage reads, he received a poetic response indicating that R. Zerahiah's approach was not considered the correct one. See *Teshuvot Min Ha-Shamayim* 61.

²² See <<http://aa.usno.navy.mil/faq/docs/crescent.php>>.

if *molad* is understood to be an average time, as Rambam 6:1 asserts, then the actual conjunction can differ by several hours and no problem exists. It would be possible that six hours from the average conjunction could equal an amount equal to or greater than twenty-four hours from the actual conjunction.²³

First Evidence of *Molad Zaqen*

In the tenth century a great debate arose between Saadiah Gaon and R. Aharon b. Meir, one of the foremost Torah authorities in Palestine. When declaring the date of Rosh Hashanah for the year 922, R. Aharon disregarded the rule of *molad zaqen*, though the *molad* occurred after midday. He argued that *molad zaqen* should not be applied simply when the *molad* occurs after midday, instead, it is invoked only when the *molad* is 642 *halakim*²⁴ after midday. R. Aharon explained that the reason for these extra *halakim* had been lost over time, but this was the tradition. Saadiah Gaon vehemently opposed this ruling; for the next few years, the communities of Palestine and parts of Babylonia observed their festivals in accordance with R. Aharon's ruling, while the rest of Babylonia observed their holidays in accordance with Saadiah Gaon's opinion. R. Aharon's statement about this old tradition indicates that *molad zaqen* was practiced for several generations as of his time; if not, such a claim would have been considered unreasonable. The argument between R. Aharon and Saadiah Gaon centered only on the application of *molad zaqen*; but its acceptability was unquestioned.²⁵

Yet, it seems that *molad zaqen* could not have been all that old as of the time of R. Aharon. A letter dating back to 836 from an exilarch found in the Cairo Genizah indicates that *molad zaqen* was not used in that year even though, based on the current rules of the Hebrew calendar, it should have (Stern 184-185).²⁶ Additionally, R. Sherira Gaon (b. 906 – d. 1006)

²³ For details see <<http://www.biu.ac.il/JH/Parasha/eng/bo/levinger.html>>.

²⁴ *Halakim* (sing. *belek*) are units of time. Each *belek* is the equivalent of 3.33 seconds.

²⁵ Sacha Stern, "Calendar and Community: A History of the Jewish Calendar 2nd Century BCE – 10TH Century CE." (New York: Oxford University Press, 2001), pp. 264–268.

²⁶ See Sheldon Epstein, Bernard Dickman, and Yonah Wilamosky, "A 5765 Anomaly," *Tradition* vol. 38, #3. New York: Fall, 2004 footnote 39 for a counter opinion that this letter does not contain evidence of *molad zaqen* being violated. However, see Raḥamim Sar Shalom, "*Matay Nosad Ha-Luab Ha-Ivri*," Sinai vol.

chronicles the death of R. Aḥai b. R. Huna as Sunday, 4 Adar, 506.²⁷ This date would not have been possible had *molad zaqen* been applied (Stern 195).²⁸ In fact, there is no source prior to R. Aharon that directly mentions the concept or use of *molad zaqen*. There is no evidence that this principle existed,²⁹ only that it did not.³⁰

Nowhere else does the Talmud directly discuss *molad zaqen*, though subsequent authorities interpret the meaning of the aforementioned passage to include it. Those authorities lived in a time period when *molad zaqen* had become a longstanding tradition and they, therefore, may have unknowingly retrofitted *molad zaqen* back into the *Gemara* since they presumed it was Talmudic in nature.³¹

102. Jerusalem: 1988, pp. 26–51 and <<http://www.daat.co.il/daat/shabat/luach/matay-2.htm>> for strong evidence in Stern’s favor that the letter does in fact indicate that *molad zaqen* was violated that year.

²⁷ *Igeret R. Sherira Gaon*.

²⁸ This date is problematic with the current calendar’s rules for other reasons, as well. See Stern 182-183.

²⁹ Sar Shalom conclusively proves that the tremendously detailed description of the Hebrew calendar in al-Khwarizmi’s work from 823/4 cannot be considered as proof as it is clearly a later interpolation. Also see Stern 185.

³⁰ The historical evidence seems to present concerns for the opinions of *Rambam Sefer Hamizvot*, *aseh* 153 and *Ramban Sefer Ha-Zekhut Gittin* 34b. These opinions appear to assert that one can adjust the calendar only when a *Sanhedrin* exists. Thus, post-talmudic rabbis would not have been authorized to modify the calendar. But others apparently disagree, as seen in the opinion cited by Rabbenu Ḥananel, *Pesahim* 58b and *Tosefot Arakhin* 9a. The language used indicates that they had no problem with post-talmudic rabbis adjusting the calendar. For a more detailed description of the development of this calendar see Stern 155–268. For an overview of the history of *semikhab* and its relationship to the *Sanhedrin* see H.Y. Borenstein, “*Mishpat Ha-Semikhab Ve-Korotebah*,” *Ha-Tekufah* vol. 4. Tel Aviv: 1918, pp. 374–426. Additionally, see Bernard Dickman, “The Beginning of the Jewish Calendar,” *Hakirah* vol. 8. New York: 2009, pp. 225–227 for evidence that Rambam does not require a *Sanhedrin* to exist in order to modify the calendar.

³¹ During the debate between Saadiah Gaon and R. Aharon, Saadiah Gaon, or one of his contemporaries, did argue that the Talmudic statement was referencing *molad zaqen*. See Stern 266.

What Changed?

The two reasons given for *molad zaqen* are based on sighting of the new moon. One opinion was that it is dependent on lunar visibility in Jerusalem and the other required only visibility somewhere in the world. Perhaps ninth-century advancements in astronomy and geography not only allowed for such interpretation but made it necessary.

It was during this time period that the Islamic *Bayt al-Hikma*, House of Wisdom, operated under the tutelage of the Abbasid caliph, Abu Jafar Abdullah al-Ma'mun ibn Harun (b. 786 – d. 833). The *Bayt al-Hikma* housed some of the world's leading scientists, facilitating constant and tremendous advancements in science. Muḥammad ibn Musa al-Khwarizmi (c. 780 – c. 850), most famous for “discovering” algebra, was one such leading scientist and he was preoccupied with the early Indian *siddhanta*, traditions and scientific recordings. Around the year 825, al-Mamun had al-Khwarizmi compose an abridged version of the *siddhanta*. Additionally, al-Khwarizmi authored two star tables known as *Zij al-Sindhind*. These tables are currently known to be the oldest extant Islamic *zīj*, star tables. These works became widely popular, giving the average Muslim the ability not only to know the positions of the celestial objects, but to know the time of day with accuracy, lending the knowledge of appropriate prayer times throughout the day. Additionally, the information contained in these works provided the tools to calculate lunar visibility with ease. Muslims, adhering to a lunar calendar based on the visibility of the crescent moon, found this information particularly useful.³² These works contained data that provided for a more accurate lunar visibility time of approximately twenty-four hours.³³ These works were so popular that they were still used in Egypt one thousand years after their composition.

It was also during this time that al-Ma'mun set forth to accurately determine the circumference of the world. Al-Ma'mun had two teams of astronomers and surveyors conduct an experiment in Sinjar, in the region of Mosul. One team traveled north and measured the solar altitude to determine when they had traveled enough distance that it had changed by

³² Lyons, Jonathan. *The House of Wisdom*. New York: Bloomsbury Press, 2009, pp. 72-73.

³³ E.S. Kennedy, and Mardiros Janjanian, “The Crescent Visibility Table in Al-Khwarizmi's *Zij*,” *Centaurus* vol. 11. New York: 1966, 75. This figure is still considered to be relatively accurate, see <<http://aa.usno.navy.mil/faq/docs/crescent.php>>.

one degree. The other team did the same while traveling southward (Lyons 69). The two then met up and compared data and found that one degree equaled fifty-six miles. When multiplying this by the requisite 360 degrees to attain the full circumference, al-Ma'mun came to a relatively accurate figure of 20,160 miles.³⁴ Additionally, al-Khwarizmi, very possibly a member of al-Ma'mun's experiment (Lyons 72), composed a descriptive map of the known world including locations of many cities, *Kitab Surat al-Ard*. Until this work, Claudius Ptolemy's (c. 90 – c. 168) works were generally accepted and al-Khwarizmi's *Kitab Surat al-Ard* corrected many inaccuracies found in Ptolemy's earlier work (Lyons 89).³⁵

These advancements and writings in geography were extremely well received and were of great significance to Muslims. Muslims could now determine the proper *qibla*, direction, prior to praying so that they may face Mecca. The religious significance of this new geographic knowledge catapulted its widespread dissemination throughout many countries (Lyons 88).

Revisiting *Rosh Ha-Shanah*

These two scientific developments may likely have shaped a newer understanding of the aforementioned passage in Tractate *Rosh Ha-Shanah*.³⁶ As mentioned above, the simple reading of that passage does not contain any reference to *molad zaqen*. A literal interpretation of that passage is that lunar visibility is six hours after the *molad*; therefore, if the *molad* was prior to midday the *beit din* can rely upon the testimony of witnesses claiming to have seen the new moon prior to sunset. Should the *molad* be after midday, *beit din* cannot accept such testimony because it would have been impossible for the witnesses to have sighted the moon. However, once the Islamic scientific advancements were popularized, presumably, it became increasingly difficult to understand the *Gemara's* statements because then current science proved that it is impossible to sight the moon six hours after the *molad*. Rather than to assume the words of the *Gemara* to be erroneous, the ninth century sages may have reinterpreted this text us-

³⁴ See Franz Rosenthal, *The Classical Heritage in Islam* (Great Britain: University of California Press Berkeley and Los Angeles, 1975), 215. Rosenthal comments that some documents indicate one degree equaling 56.66 miles. He theorizes that the difference could be attributed to the north team arriving at one figure and the south team at the other.

³⁵ One such correction was to reduce the Mediterranean Sea from sixty-two degrees to only fifty-two.

³⁶ *Rosh Ha-Shanah* 20b.

ing R. Zeraḥiah's approach. The more accurate duration of time of visibility, twenty-four hours, was instead assumed in the *Gemara*, thereby necessitating the focus of the *Gemara* to be at the easternmost point from Jerusalem, thus allowing for both the *molad* and a moon sighting on the same day. While lunar visibility would not be achieved in Jerusalem itself should the *molad* be just prior to midday, at this easternmost point the moon could be seen just prior to sunset. It could no longer be assumed that the admission of witnesses was the subject of the passage, because those who observed the new moon in this case were irrelevant, as they would have been too far away from the *beit din* in Jerusalem to testify; with no other means of explanation, the concept of *molad zaqen* was born. Interestingly, the overall structure of this theory is very similar to Ravad's overall contention with R. Zeraḥiah's approach. Ravad claims that R. Zeraḥiah's approach is erroneously predicated on its author's own scientific understandings being thrust back into the words of the Talmud. Ravad contends that those in China, the easternmost part referenced by R. Zeraḥiah, are clearly not the subjects of the Talmud's discussion. Although the details of the theory presented above and the details of Ravad's questions are very different, the nature of both arguments is essentially the same.³⁷

Moreover, there appears to be some textual proof that *molad zaqen* was not the original interpretation of this passage in Talmud Bavli. The authorities of the Talmudic era and early geonic era all believed in six-hour lunar visibility and interpreted the Talmud Bavli accordingly.³⁸ In fact, it seems probable that the passages from *Midrash Tanḥuma*,³⁹ Talmud Yerushalmi,⁴⁰ *Pesiqta de-Rav Kabana*,⁴¹ and *Midrash Ha-Gadol*⁴² that directly discuss lunar visibility being six hours after the *molad* are not just similar to each other but are actually variations of the Talmud Bavli itself. Talmud Bavli had Abba, R. Simlai's father, chastising Shmuel for attempting to create a calendar by citing a source that appears to indicate that lunar visibility is six hours after the *molad*. *Midrash Tanḥuma* has R. Shmuel b. Abba making a similar statement but its intent is to define lunar visibility at six hours from the *molad*. Talmud Yerushalmi's account has R. Simlai expressly stating that lunar visibility is six hours after the *molad* and both *Pesiqta de-Rav Kabana* and *Midrash Ha-Gadol* have R. Simlai crediting R.

³⁷ See Ravad *Katuv Sham*, *Rosh Ha-Shanah* 20b.

³⁸ See footnotes 14–19.

³⁹ *Midrash Tanḥuma*, Bo 10 (Buber).

⁴⁰ *Yerushalmi*, *Rosh Hashanah* 14a.

⁴¹ *Pesiqta de-Rav Kabana*, *Ha-Hodesh* 54b (Buber).

⁴² *Midrash Ha-Gadol*, Bo 12:2.

Shmuel with this assertion. The fact that these sources' focus is clearly lunar visibility at six hours, seemingly the intention of the Talmud Bavli, and the striking similarity of the sages mentioned—R. Simlai, R. Simlai's father Abba, R. Shmuel b. Abba, Shmuel, and R. Shmuel—strongly suggests that these passages are all really different accounts of the same original source, just slightly corrupted through transmission. It therefore stands to reason that the original passage was not at all pertinent to *molad zaqen*.

Summary of *Molad Zaqen* throughout History

Rambam, *Hilkhot Qidush Ha-Hodesh* maintained that the word *molad* in Talmudic texts refers to the average time of a lunar conjunction and thus would not have had any difficulty reconciling the text of Rosh Hashanah 20b with the real-world reality. However, most early sources believed *molad* referred to the actual time of conjunction. As such, they understood that Talmudic texts reflect the belief that the moon was visible six hours after a lunar conjunction. As scientific observation advanced and knowledge of geography became more widespread, the interpretation of Talmud Bavli's passage shifted and *molad zaqen* seems to first emerge sometime in the ninth century. Contemporary knowledge at this time has lunar visibility at significantly more than six hours; to interpret the Talmud Bavli, it became necessary to attribute its discussion to those eighteen hours behind Jerusalem.

Less than a century later, *molad zaqen* found itself in the fierce argument between Saadiah Gaon and R. Aharon b. Meir, dividing the nation of Israel and its observance of festivals. By their time, *molad zaqen* had already been widely accepted as an intrinsic rule of the calendar; its details, though, were the subject of dispute. Saadiah Gaon fully accepted the notion of *molad zaqen* though he still held on to the literal interpretation of the Talmud Bavli of the moon's visibility at six hours after midday.⁴³ Saadiah Gaon, like other early authorities, assumed that the focus there was lunar visibility in Jerusalem and the sages did not want to declare Rosh Hashanah on a day that the moon would not be visible in Jerusalem. It is not clear, though, how Saadiah Gaon reconciled his assessment of lunar visibility with actual observation. R. Aharon b. Meir argued that one invokes this rule only if the *molad* is 642 *halakim* after midday but did not present the logic behind these added *halakim*. *Molad zaqen* was implemented both by those advocating a six-hour lunar visibility and by those

⁴³ See Rashi, *Rosh Hashanah* 20b.

promoting a twenty-four-hour visibility. Centuries later, R. Zerahiah expresses in his writing that *molad zaqen* had been taken one degree further by interjecting it into the passage from Talmud Bavli with the accepted new values of lunar visibility and its geographical significance. By this time, the six-hour lunar visibility had been completely abandoned. ❧