DEAD SEA DISCOVERIES 23 (2016) 79–87

Dead Sea Discoveries

BRILL

brill.com/dsd

# A Response to Eshbal Ratzon, "Methodological Issues concerning the Astronomy of Qumran"

*Dennis Duke*
Florida State University
*dduke@fsu.edu*

*Matthew Goff*
Florida State University
*mgoff@fsu.edu*

**Abstract**

This article offers a brief response to a recent article by Eshbal Ratzon, in which she is critical of an article we published in *DSD* on the Aramaic Astronomical Book in 2014. Ratzon raised several methodological issues with respect to our essay. In this response we attempt to clarify the relationship of our paper to those issues.

**Keywords**

Aramaic Astronomic Book – astronomy – 4Q208 – 4Q209

A recent paper in this journal by Eshbal Ratzon (henceforth ER) raised several methodological issues with our paper "The Astronomy of the Qumran Fragments 4Q208 and 4Q209."[1] Here we will try to clarify the relationship of our paper to those issues.

1 Eshbal Ratzon, "Methodological Issues Concerning the Astronomy of Qumran," *DSD* 22 (2015): 202–9. See also her "The Gates Cosmology of the Astronomical Book of Enoch," *DSD* 22 (2015): 93–111; eadem, "The Gates of the Sun and the Moon in the Astronomical Book of Enoch," *Tarbiz* 82 (2014): 497–512. For our article which Ratzon engaged, see Dennis Duke and Matthew Goff, "The Astronomy of the Qumran Fragments 4Q208 and 4Q209," *DSD* 21 (2014): 176–210.

 | DOI 10.1163/15685179-12341370

In the introduction to her paper ER states that we "use the astronomical model of lunar elongation . . . to compute the times of the moon's visibility and invisibility" and "conclude that the times written on the Aramaic fragments are closer to reality than the times written in the Babylonian sources of the AAB, some of which are known to us from tablet XIV of the astronomical collection the Enuma Anu Enlil (EAE)." While we do propose a simple astronomical model that is consistent with the numbers in the AAB, the fact that the numbers in the AAB are "closer to reality" is a simple fact that requires no conclusion on our part. What is not a simple fact is the claim that the EAE is "a Babylonian source of the AAB." Instead this is a conjecture by various modern scholars which is not, in our opinion, supported by nearly enough evidence to deem it conclusive. In addition, we are not aware of a single time interval in the AAB fragments that is "known to us from tablet XIV of the . . . EAE," and ER provides no justification of such a claim.

Also in the introduction ER claims that our use of the fact that the lunar elongation increases in the interval between sunset and moonset "proposes a new approach to the subject." However, the identical criterion—a constantly increasing elongation—was used throughout the Babylonian System A models for both the Moon and the planets that date to around 400 BCE, and by many subsequent models, both Babylonian and Greek (in fact, we know of no exceptions, but that does not mean there are none).[2] What is true, and clearly stated in our paper,[3] is that the time intervals in the EAE, which was written about a thousand years earlier than 4Q209, do not take a constantly increasing lunar elongation into account.

Finally, in the introduction ER states that the fragments found in 4Q208 and 4Q209 are part of a "Synchronistic Calendar." If it ever existed, such a calendar would have been used to reconcile the difference of about eleven days between twelve lunar months and one solar year, and would likely mean that the original document from which the fragments survive described in turn at least twelve, and perhaps as many as thirty-six, months. In any event, all of this is also modern speculation and is not strongly supported by evidence.[4]

---

2 Excellent and imminently accessible introductions to the state of astronomy in the ancient Near East may be found in Otto Neugebauer, *The Exact Sciences in Antiquity* (New York: Dover, 1969 [orig. pub., 1957]).

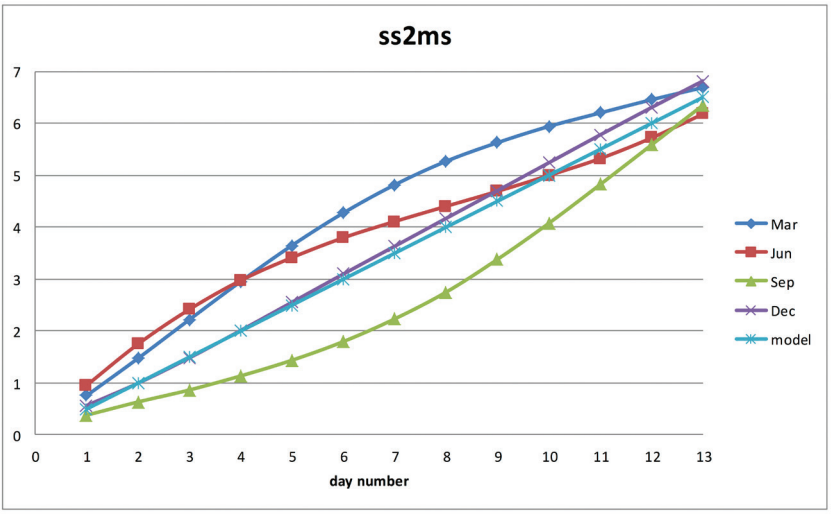
3 Duke and Goff, "Astronomy," 191.

4 For elaboration on this point see Henryk Drawnel, *The Aramaic Astronomical Book (4Q208–4Q211) from Qumran* (Oxford: Clarendon, 2011), 32: "calling the whole lunar calculation a 'synchronistic calendar' (Milik 1976)—where the movement of the sun is synchronized with that of the moon—is a misnomer that does not reflect the purpose and content of the Aramaic text."

### Day-Night Ratio

In this section ER states that we base our "computations on the assumption that 'sunset to sunrise is always 1/2 a day'" and that "this assumption is astronomically incorrect." Of course we know it is incorrect, and we never claim that it is correct. What we do claim is that *if we assume that the original scheme used that assumption as a simple approximation for computation in a schematic month*, then we can find a model that is consistent with the pattern of time intervals found in the fragments. Thus while the fact "the ratio of the longest to shortest day is not unity" is attested widely, from the EAE to Babylon to Greece and to *1 Enoch*, this does not in itself imply that the author of the scheme found in the AAB felt compelled to use it in his schematic construction even though he was certainly aware of it.

A more interesting issue is what would the pattern of rising and setting times look like in our model if we did use a longest to shortest day ratio of, say, 2:1 as ER suggests? In the years before our paper was published we did just that, and some sample results for the time interval sunset to moonset divided by the interval sunset to sunrise, i.e., *ss2ms* in our paper, in the first half of a month are shown in the figure below. The results for 30-day months beginning in March, June, September, and December, i.e., near the equinoxes and solstices, and the large difference between those months and the linear results from our model, very strongly suggest that the author of the original scheme did not implement a variation in day length in his calculations.



Therefore ER is incorrect when she concludes that *our* "assumption that sunset to sunrise is always 1/2 day does not acknowledge the inherent contradictions that this assumption creates between the AAB and the Ethiopic version of *1 Enoch*, between the AAB and the EAE, and between the AAB and reality." What would be correct is that since the pattern of time intervals that take into account the annual changes in length of day does not agree with the pattern we find in the fragments, our *conclusion* is that the author of the scheme was apparently not too concerned with the differences between his model and reality.

It is also the case that the decision of the scheme's author to disregard length of day variation does not, in itself, rule out his recognition of the movement by the Sun and Moon through a scheme of gates on the eastern and western horizons. It is true that if the author was imagining an observer at some northern geographical latitude typical of the Middle East then our simple model implies that he was also assuming that the ecliptic circle and the equator circle were identical, i.e., technically, the obliquity of the ecliptic was zero, and all rising and settings of the Sun and Moon would be at the east and west points of the horizon. But on the other hand, if the author of the scheme was for whatever reason imagining an observer on the equator, and was also assuming a typical obliquity of about 24°, then the rising and setting directions of the Sun and Moon would still oscillate north and south through the gates even though the length of day is constant throughout the year on the equator. Either way, the calculations of the time intervals in our model would be the same and would still agree with the numbers found in the fragments.

### Precision

In this section ER takes issue with the fact that in our model we had to assume an initial value for the lunar elongation on the first day of the month, and that "value has no textual base in the scrolls; rather it was only added so that the results would match the numerical values found in the scrolls." However, we have access not to "the scrolls" but only to the surviving fragments, and among the fragments there is nothing about the first day of any month, so not only do we never find an initial value of elongation, we never find a name of a month or a sequence number for the month in any kind of year.

Also in this section ER is critical of the fact that the model values we report in the tables for comparison to the values found in the fragments are rounded, in fact to the nearest 1/14th, and claims that this "removes evidence that would

be helpful in evaluating their theory." The main issue is not our rounded values, for the exact values can be easily computed by anyone using either the equations we give on pp. 193–95 or the simple procedure we give on p. 196, and so there is no "removed evidence." Rather the issue is that the values given in the fragments are just multiples of 1/14th, so whether those were originally rounded by the author after some computation, or possibly created by some procedure that results directly and only in such multiples, they are all we have, and so of course we want to compare our results in the same units we find in the fragments.

### Matching the Data from AAB

In this unit ER disagrees with our model in which the full moon never occurs on the fifteenth day of any month, since Drawnel identifies two patterns: a 29-day (hollow) month in which full moon falls on the 14th day, and a 30-day (full) month in which full moon falls on the 15th day. Why this creates a problem for us is not discussed by ER, but we can easily explain why it is not a problem. First, as explained in detail in our paper,[5] if the time interval between astronomical new moons is always 29½ days, as assumed in our model, then the time between astronomical new moon and full moon is always 14¾ days. But since the first day of the *civil* month is (always in our model, and almost always in reality) between one and two days *after* astronomical new moon, then the time when the moon reaches full moon is sometime between noon on day 13 and noon on day 14.

In contrast with our model, which is entirely conventional in starting each month on the evening when the Moon is first visible just before sunset, Drawnel takes a different and contrasting route. Because the needed information on how the month starts is missing from the AAB fragments, Drawnel assumes that he can supplement the information in the fragments with information on the start of the first day found in *1 En.* 73:4–8.[6] In his interpretation, the month starts in the *morning*, and it is this convention that makes it possible for a full moon to fall on the 15th day of a 30-day month.

Also in this section, ER writes "while demonstrating the consistency between their results and the data found in the AAB, the authors quote all values from the AAB to be from the same kind of month (a full month of 30 days)." This does

5 Duke and Goff, "Astronomy," 192 and n. 18 on the same page.

6 Drawnel, *The Aramaic Astronomical Book*, 267–85.

not accurately reflect what we write. What we do write is that it is possible, by choice of the initial lunar elongation on day 1 of a month, to construct a 30-day month that is consistent with *all* the fragments, and that with an *alternate* choice of initial lunar elongation, it is possible to match *all* the fragments to alternating 29- and 30-day months. Or more concisely: we can find no way to decide, based on the collected fragments, whether the author of the AAB was constructing exclusively 30-day months or a mixture of 29- and 30-day months. Thus ER's comment that 4Q209 7 iii and 4Q209 7 ii are in different months in Drawnel's scheme is irrelevant regarding our model because, as discussed above, our model and Drawnel's differ regarding a fundamental assumption.

### Mathematical Complexity

In this section ER claims that regarding the underlying mathematics, our "methods are much too complicated for the ancient authors of the AAB," that we "employ mathematical variables, a relatively recent mathematical tool, and substitute them for functions," that our "use of simpler mathematical operations, such as addition, subtraction, multiplication, and division of fractions is more difficult than the mathematical knowledge applied in the Dead Sea Scrolls," and that "the assumption that this mathematical knowledge existed in Second Temple Judea, but is not documented on any surviving scrolls, needs further evidence."

For any of these assertions to be relevant to our paper we need to know something about who the author of the scheme found in the fragments actually was, and when and where he lived, and of course neither we nor ER know any of these things. Another thing that we do not know is whether the scribe, or scribes, who wrote the document containing 4Q208 and/or 4Q209 had anything to do with the creation of the underlying scheme or even understood how the numbers were computed. Since we do not know when or where the author lived, we have no reason to think that whatever else we might know about general mathematical skill found in the Dead Sea Scrolls, or more broadly anywhere in Second Temple Judea, was at all relevant to the skills of our author, and we certainly do not assume that his "mathematical knowledge existed in Second Temple Judea."

But given that the fragments demonstrably exist, and that the number sequences we find are not simply trivial sequences of multiples of 1/14th, i.e., as discussed on p. 202 of our paper, there is clear evidence that the numbers were computed very carefully, we can be certain that *someone* had the necessary

skill, and that somehow the knowledge of that person ended up on a document in a cave in Qumran.[7]

## Lunar Elongation

In this section ER questions whether "the basic idea that lunar elongation was the astronomical model at the basis of the AAB." ER points out that "in the Aramaic fragments from Qumran the main focus is on the temporal aspects of lunar theory, comparing the times of the rising and setting of the moon with the rising and setting of the sun" and "all references to the phenomenon of lunar elongation are completely absent from the AAB." She concludes that "the absence of a mention of lunar elongation might be a coincidence; but a more probable explanation is that the absence of this term is related to the entirely different cosmology reflected in the AAB fragments," thus promoting to the level of established fact something that is speculated but far from proven: "the entirely different cosmology reflected in the AAB fragments."

Turning to specifics, ER summarizes this cosmology as follows: the AAB authors consider the gates on the horizon, through which the Sun and Moon rise and set, to be projections of the zodiacal signs onto the horizon, and "as the spatial aspects of the lunar theory are discussed only from the horizontal point of view—and as far as we know, lunar elongation is not at all mentioned in the AAB—it is implausible to assume that lunar elongation was the basic concept underlying the entire computations of the lunar theory represented in the AAB."

The fact is that all of our computation use mean motions, i.e. average speeds, to compute arc lengths, i.e. elongations, using (elongation) = (speed) × (time interval), so in a very real sense elongation, in the way we use it, is nothing more or less than a proxy for time interval. This use of arc lengths and time intervals lies at the heart of Babylonian System A, which dates to about 400 BCE, and continues to be used in Babylonian and Greek astronomy for centuries thereafter. It is also a fact that both Babylonian and Greek astronomers knew very well that *mean* elongations of the type we are using, and that the ancients used, are not directly observable in the sky but must be calculated, and then be corrected with another calculation to get the true elongation as observed in the sky. This final correction is evidently not used by the author of

7 Neugebauer, *The Exact Sciences in Antiquity*, shows that in general there is ample evidence for complex mathematical thought in antiquity.

the astronomy found in the AAB. So the elongations we use are in fact simple proxies for the time intervals that ER contends we should use.

This section concludes with a claim that "the AAB's theory on what happens to setting luminaries also contradicts the theory of lunar elongation" because "the AAB posits that after setting, all luminaries went back eastwards *above* the firmament through the northern areas of the sky (*1 Enoch* 72:5; 4Q209 23 6; 4Q210 1 ii 2a 17), thus not moving in a circular movement."

Here are the cited lines and those that precede and follow:

*1 Enoch* 72:4–6[8]:

4. The first one to emerge is the great luminary whose name is the sun; its roundness is like the roundness of the sky. It is entirely filled with fire, which gives light and heat.
5. The wind blows the chariot where it rises, and the sun sets from the sky and goes back through the north in order to reach the east. It is guided so that it enters that gate and gives light in the firmament.
6. This is how it emerges in the first month through the large gate; it emerges from the fourth one of those six gates on the side where the sun rises.

4Q209 23 4–7 (superscripts refer to *1 Enoch*):[9]

4. . . .[77:2]And the great quarter (they call) the West quarter, because there
5. [go the st]ars of heaven where they set and where they enter; and all of them are stars. And for this reason they call it West.
6. [[77:3]And the north (they call) North] because in it all the setting (bodies) of the sky hide and gather together and revolve, and go to the East of the sky.
7. [And the east they call Ea]st because there the vessels of the sky arise, and also (they call it) East because th[er]e they rise *vacat*

4Q210 1 ii 2a 17[10]:

14. and devastation. And the twelve gates of the four quarters of the sk[y] have been completed
15. because it is the first; and they call the south South be[cause
17. of heaven where they set and where they en[ter

8 For this translation, see George W.E. Nickelsburg and James C. VanderKam, *1 Enoch 2* (Hermeneia; Minneapolis: Fortress Press, 2012) 416.

9 Drawnel, *The Aramaic Astronomical Book*, 192.

10 Drawnel, *The Aramaic Astronomical Book*, 220.

18. because there lunar months arise when [they] are brought to completion

There is nothing in either Qumran text to suggest that any luminary "went back eastwards *above* the firmament through the northern areas of the sky." In fact, 4Q209 23 6 says of the North that "in it all the setting (bodies) of the sky hide and gather together and revolve, and go to the East of the sky," and the word 'hide' seems to imply exactly the opposite of "*above* the firmament."

Regarding the lines from *1 Enoch* 72, we suggest that "the sun sets from the sky and goes back through the north" means that the sun does indeed go below the horizon, and it does so on an arc (a circle of constant declination, to be precise) that is slanting downward and from south to north, and the phrase "it emerges from the fourth one of those six gates on the side where the sun rises" means that it does subsequently rise in the east.

To suggest then that the sentence "It is guided so that it enters that gate and gives light in the firmament" means, as ER claims, that it gives light *above* the firmament would imply that the sun would be clearly visible, and hence "filled with fire, which gives light and heat," and in the northern sky, all through the night. We find it very difficult to believe that the author of the scheme found in the Qumran texts would entertain such a fantasy, and we certainly do not conclude on the basis of this argument that he did.[11]

## Conclusion

In this section ER writes of us that "their work offers an advantage to further research on the AAB" and "we can only hope that other scholars will follow their lead and continue to apply an interdisciplinary approach while studying this complicated text." Here finally we find a common ground which we enthusiastically endorse.

## Erratum

On page 195 of our paper, in the fourth equation, there is a misprint. The denominator $m$—2 should be $m$—1.[12]

11 For a thorough discussion of the relationship of *1 Enoch* 72 to the AAB see Drawnel, *The Aramaic Astronomical Book*, 292–301.

12 Duke and Goff, "Astronomy," 195.