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Zemannim: On the Introduction of New Constructs in Halakhah

It is a truism that Halakhah responds to scientific and technological innovations. But sometimes scientists and technologists develop new or modified notational conventions or conceptual constructs that measure or specify certain phenomena with precision. The question *posekim* face in such cases is whether, when and how such innovations impact halakhic determinations concerning the phenomena that the innovations are designed to address. How should the new scientific language and conceptual frameworks enter halakhic decisions? When should traditional methods prevail, and when should the new constructs be utilized?

This paper deals with four examples of the phenomenon just described, all drawn from the topic of *zemannim*—the determination of times for various events, such as the onset and departure of *Shabbat* or the times of various *tefillot*. Specifically:

1. Datelines are notational constructs for longitudinal lines that can specify the place where the new day begins.

2. Depression angles are mathematical measurements that allow astronomers to specify levels of darkness with accuracy.

3. Clocks are a technological innovation that allow us to specify time more precisely.

4. A phrase like "the number of minutes after sunset" is a mode of expression used to communicate various *zemannim*.

There are yet other such constructs within *zemannim*, such as sea-level and the classification of stars. Similar examples also exist in other domains where measurements, statistics, probabilities, and other mathematical /

scientific notions are relevant. But my discussion is confined to the four categories just mentioned.

I offer no general solution to determine how new concepts of time measurement impact upon Halakhah, just some examples to motivate careful investigation.[1] In fact, the diversity of halakhic options that result from analyzing the examples might indicate there are no well defined principles. Rather, *posekim* must judge the impact of these constructs carefully and strive to understand and either accept or reject the assumptions and reasoning that the new constructs introduce. The discussion assumes some familiarity with the halakhic topics discussed; the notes provide additional background.

Datelines

Going back at least eight hundred years, scholars hypothesized a scenario in which two people leave a particular locale, travel in the eastern and western directions respectively, traverse the globe and eventually return to their point of origin. They correctly concluded that (regardless of how long it takes for them to return) relative to one who stayed at home, the person who travelled west would assume it is a day earlier and the one traveling east would assume it was day later.[2] A mechanism is needed to resolve the issue. The dateline, to be sure, is a construct

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1. In most of my examples, I assume that both the construct and the associated reality were understood correctly by *posekim*. There are areas, such as latitude, where that was not uniformly the case.

2. This was of course validated when Magellan first circumnavigated the globe. The individual travelling west would observe one less sunset, and the individual travelling east would observe one additional sunset, causing each to believe it was a different day in the calendar. In modern times one can imagine a scenario in which two planes circumnavigate the globe in exactly 24 hours flying in opposite directions, leaving, say, from New York on Tuesday afternoon at 1 PM, and returning to New York 24 hours later. Those flying west, staying home, and flying east see zero, one and two sunsets respectively. Upon returning, those who flew west never seeing a sunset might assume it is still Tuesday. Those who flew east seeing two sunsets might assume it is already Thursday. Those staying at home know that it is Wednesday. After observing sunset in New York on Wednesday, those flying east will need to convince themselves that they will have observed the two sunsets of Tuesday and Wednesday a total of three times, observing the end of the same day twice. Those flying west (or east) and arriving at the same place 24 hours later must know that it is 1 PM a day later. A dateline is an artifice that solves this problem. For those flying over the dateline heading west, the day advances. Those flying east can think of each time they observe nightfall as advancing the day forward; however, crossing the dateline in the eastern direction moves the day back to the preceding day.

If two of three newborn triplets were aboard the two planes, while one stayed home, the day of each child's *berit* would present an interesting halakhic quandary.

created by convention; despite its artificiality, it provides an effective and practical solution.

Is the notion of a dateline, however, an unavoidable halakhic necessity? I presume that many believe the answer is yes, and that the question is only how to determine where the dateline is. But let me formulate the opinion of a number of *posekim* who questioned the very need for a dateline.[3]

Consider the following simple decision rule: Choose any specific location and determine how the first or current community of Jews came to the area, assuming, as we do, that humanity's origin was in the Middle East. As they travelled from west to east (Israel to India, for example), their *Shabbat* would start continually earlier; as they travelled from east to west (Israel to Europe, for example), their *Shabbat* would start continually later. There was no knowledge of datelines or other global measurement systems. Rather, each community established its day of *Shabbat* based on the direction from which it came. I assume that it is highly unlikely that the first (or current Jewish) inhabitants of Japan or the Philippines or New Zealand did not arrive via Asia or that the first visitors to Hawaii did not arrive via North America. Certainly, the (Jewish) communities that currently inhabit those locations can trace their origins.[4] Can this create theoretical or even real situations that still need to be adjudicated?[5]

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3. These include R. Tzvi Pesach Frank, *Har Zevi, Oraḥ Ḥayyim* (henceforth *O.Ḥ.*), 138; R. Menachem Kasher, *Kav ha-Ta'arikh ha-Yisraeli*; R. Isser Zalman Meltzer, in letters referenced below; and R. Yonason Steif, *Limmudei ha-Shem, Parashat Bereshit*, 156. The formulation of their view has been slightly simplified/modified to enhance clarity. A sequence of *shiurim* by R. Aaron Rakeffet-Rothkoff at Gruss *Kollel* at the end of 2004 covered multiple sources including: Radbaz, *Shut Radbaz* 1:76; R. Yaakov Emden, *Mor u-Keẓi'ah, O.Ḥ.* 344; and R. Yosef Shaul Nathanson, *Sh'oel u-Meshiv, mahadura* 4, part 2, 154; as well as other authorities who provide support for their point of view. A *shi'ur* by R. Zalmen Koren on January 9, 2011 in Jerusalem, in which he discussed recently uncovered letters by R. Meltzer on this topic, also supports the approach taken here.

4. Given the Seward purchase in 1867, the case of Alaska might raise complex issues. In addition to the move from the Julian to the Gregorian calendar, the day of the week was changed when Alaska moved from one side of the international dateline (the Asian) to the other (the North American). Some might argue that a potential community from an earlier period may have established a precedent before it disappeared. Alternatively, one could argue that once a community disappears, its customs disappear as well. Thus, any customs of a Jewish community from before the Seward purchase evaporate; a place that loses its community maintains no custom.

5. In theory two groups can arrive from opposite directions to some island in the Pacific and need to establish the day of *Shabbat*. This method may also need to establish what day it is when flying over uninhabited land or an ocean. I have also avoided any discussion of whether there may be an additional need for an individual to maintain a personal count for, say, *Shabbat*, independent of the community he may have traveled to during the week. Assume that it is Sunday in place A and Monday in place B and one travels from A to B in a few hours without seeing any sunset. Independent of the issues discussed, it has been argued that during his first week in place B, there would be a need to keep *Shabbat* on Sunday as well.

Certainly, but other established halakhic principles can be applied to these situations. My point is a simple one. A straight longitudinal line or one that bends with the edge of a continent is a construct used to describe the earth (or other round objects); it is a measurement system, not a description of the object's intrinsic properties. Even if the use of such a line is not fundamentally foreign to the halakhic determination of the day of *Shabbat*, other, older methods may be more consonant with existing halakhic principles, and might solve the problem without need for a line.[6] Yet, Ḥazon Ish, R. Yeḥiel Mikhel Tukitzinky and many other *posekim* advocated use of a dateline.[7]

I will not try to resolve the dispute. It should be noted, though, that the non-dateline based approach of R. Isser Zalman Meltzer and others would celebrate *Shabbat* in Hawaii, Japan, New Zealand and the

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In general, it is important to differentiate between how a community is to determine the day of the week in a particular locale, and how an individual is to behave when moving between locales that observe days of the week differently. Those two issues are related but distinct; this paper is focused only on the former issue.

6. Imagine a very different geography for the Pacific Ocean, where Asia extends further east than New Zealand in the southern hemisphere, while in the northern hemisphere, Alaska occupies much of Siberia and is separated from the rest of Asia by a large body of water much further to the west. I suspect that a straight (or landmass / continent conforming) line might be viewed as less intuitive.

7. Ḥazon Ish (R. Avraham Yeshayahu Karelitz), *kuntres* 18; R. Tukitzinsky, *Yomam be-Kaddur ha-Olam*. These authorities chose 90 and 180 degrees west of Jerusalem, respectively. The former (90 degrees) relies on R. Yehudah ha-Levi (*Kuzari* 2: 19) as well as R. Zeraḥyah ha-Levi's interpretation of *Rosh ha-Shanah* 20b. This conclusion faces at least three challenges:

   1) The *gemara* in *Rosh ha-Shanah* may be interpreted differently, as Rashi and others do.
   2) Even if the *gemara* is to be interpreted in accordance with R. Zeraḥyah ha-Levi, who specifies that at noon in Jerusalem, somewhere on earth it is 18 hours earlier and the day is beginning, what he implied was a location but not necessarily a strict longitudinal line.
   3) Even if R. Zeraḥyah meant a strict longitudinal line, his source was not necessarily (entirely) traditional and may well have reflected familiarity with contemporary science.

My view is that all three are, in decreasing order, likely. I have no evidence, but R. Zeraḥyah HaLevi could be reflecting thinking of gentile scholars of his period around whose time these issues were first recorded in detail. As far as I know, there is no such recorded discussion of datelines going back to the period of R. Yehudah Halevi.

Sources supporting the 180 degrees view are midrashic, and may not provide a compelling halakhic basis. Of course, there is no evidence that either of these approaches was ever used in practical *pesak* prior to the end of the nineteenth century. One would also be hard-pressed to explain how such a degree-based rule could be applied before global measurements were in use.

Philippines according to local custom.[8] Neither the approach of Ḥazon Ish nor that of R. Tukitzinky does that.[9]

Depression Angles

Consider a depression angle[10] that measures the angle between the sun's current position and the horizon; a larger angle indicates that the sun is further below the horizon, which would mean less visible light could be coming from the sun. If a depression angle of, say, 12 degrees[11] occurs before sunrise at 4:30 AM in London and 4:50 AM in New York on the same or different days, then one can be certain that the amount of illumination from the sun is the same at those two times. It is normally assumed by those using depression angles that:[12]

> – an angle of approximately 16 degrees is equivalent to *alot ha-shaḥar,* the first light of day;[13]

8. Some prefer this approach because it conforms to local practice. There was a particularly novel opinion of R. Dovid Shapiro (*Shut Benei Ẓiyyon*, vol. 1:#14 and slightly modified in vol. 2:#10 where R. Shapiro moved the dateline a few degrees to account for the time between sunset and nightfall) that determined that the halakhic dateline happened to be about two degrees from the standard international dateline. Use of the halakhic method that examines the direction from which the original community arrived, happens to largely coincide with the international dateline and R. Shapiro's *pesak*. This fascinating topic still lacks a comprehensive historical treatment.

9. I would also argue that the non-dateline based approach makes the case of Antarctica significantly more tractable. Treating Antarctica as a land mass does not resolve the issue; how one arrived there may be more helpful.

10. To explain: Before it rises and after it sets, when the sun is only a few degrees below the horizon, illumination from the sun is apparent. The degree of illumination corresponds to what is termed a depression angle. Given the earth's tilt and rotation, computing depression angles involves spherical trigonometry, which is fortunately not needed for our purposes. Depression angles provide a mechanism that measures precisely the amount of light from the sun that is visible during the twilight period before or after sunset. Similarly, albeit without the precision, Ḥazal used terms like *mi-she-yakkir, hikhsif ha-elyon*, the appearance of small/medium stars, etc. all of which relate to the degree of darkness or equivalently the amount of residual illumination from the sun.

11. Because of the mathematical and scientific nature of the subject matter, I generally use Arabic numerals, but, when more appropriate, I spell out the word.

12. Depression angles were popularized by R. Tukitzinsky in his work *Bein ha-Shemashot* and by Leo Levi in his book *Halakhic Times* (Jerusalem, 1967). In recent times, most online internet sites that provide *zemannim* (as well as many printed calendars) use this methodology extensively.

13. Approximately 16 degrees corresponds to the more prevalent 72 minutes before sunrise, while approximately 20 degrees corresponds to 90 minutes before sunrise. There are other less common opinions about the time of *alot ha-shaḥar*, including 120 minutes before sunrise. While the *gemara* in *Pesaḥim* 94a concludes that the interval from *alot ha-shaḥar* to sunrise is the period of time needed to walk four *mil*, the 72 versus 90

— the opinions of *posekim* regarding the later point of *mi-she-yakkir* equate to around 11.5 degrees,[14] when more light is visible;

— 8.5 degrees is the most common current measurement for *ḥashekhah*, the requisite level of darkness[15] that equates to the conclusion of *Shabbat* according to the *ge'onim*.[16]

The time between sunset/sunrise and occurrences like *ḥashekhah* or *mi-she-yakkir* vary based on latitude and season; neither the appearance of three stars nor the first light of day occur a fixed number of minutes from sunset and sunrise, respectively. Depression angles capture the latitudinal and seasonal variations precisely.

Hardly a long-standing halakhic notion, depression angles first appeared in a halakhic context around the time of R. Naftali Ẓevi Berlin (Neẓiv)[17] and R. Dovid Ẓevi Hoffmann,[18] during the latter half of the nineteenth century.

Perhaps because such measurements seem so new and are certainly

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minutes debate centers around whether one walks 40 *mil* per day starting at sunrise or *alot ha-shaḥar*; does one walk four *mil* during the twilight period before and after sunrise and sunset respectively and 32 *mil* in between, or are all 40 *mil* walked between sunrise and sunset? Dividing the number of *mil* walked (40 or 32) into the 720 minutes, that equates to an average day of 12 hours, gives the period of time needed to walk one *mil* (18 or 22.5 minutes). Interestingly, at about 80 minutes before sunrise, currently available scientific measurements detect the first light from the sun (in the Middle East around either the spring or fall equinox, the time of the year all commentators assert the *gemara* is referring.) A halakhic definition of either 72 or 90 minutes before sunrise is remarkably consistent; either can be reconciled with scientific observation, although 72 minutes is much easier. The difference between approximately 80 minutes and 72 minutes can be explained either by a slightly greater level of illumination and/or a level of illumination that is visible to the average person. While 90 minutes clearly precedes the first appearance of light, it may correspond to the slightly earlier point when daytime activity begins in anticipation of the day beginning.

14. This is the point when there is sufficient light to recognize a friend at four *ammot*. This *zeman* is broadly disputed. Extrapolating from the custom of certain *posekim* in Jerusalem (see Benish, chapter 23, esp. page 212) would set *mi-she-yakkir* at over 13 degrees. At the other extreme, R. Feinstein (*Iggerot Mosheh, O.Ḥ.* 4:6) seems to support a point of *mi-she-yakkir* of less than 9 degrees. R. Feinstein assumes *mi-she-yakkir* occurs 35 to 40 minutes before sunrise, an opinion that is different than commonly accepted *pesak*.

15. The point at which *Shabbat* ends is referred to as *ḥashekhah*. This is more commonly referred to as the appearance of three (small) stars.

16. With a few exceptions, the opinions of a vast majority of *posekim* equate to a point less than or equal to 8.5 degrees, with almost all falling in a range from approximately 7.5 to 9.3 degrees. Note that using 7.5 to 9.3 degrees for the conclusion of *Shabbat,* as opposed to approximately 6 degrees, parallels the extension from three medium stars to three small (and adjacent) stars.

17. *Melammed le-Ho'il*, # 30. R. Hoffmann considered dispensing with *mi-she-yakkir*, given the ability to specify *alot ha-shaḥar* precisely based on depression angles.

18. Benish (453) has a copy of a table using depression angles prepared at the request of Neẓiv. I do not know Neẓiv's reaction to the table, or how he might have used it.

modern, adoption of depression angles in Halakhah has been uneven. On one end of the spectrum, for example, R. Mordechai Willig,[19] consistent with the practice of R. Joseph B. Soloveitchik, applies depression angles across the board, to all determinations concerning *alot ha-shaḥar*, *mi-she-yakkir*, the end of *Shabbat*, etc. In fact, he claims that, in the more northern latitudes of Europe, those who waited 72 minutes after sunset to end *Shabbat* were more closely following the opinion of the *ge'onim* than that of Rabbenu Tam. If one waits for three small stars,[20] then in Vilna, one would have to wait approximately 72 minutes[21] and perhaps longer during the summer; similarly, Rabbenu Tam's 72 minutes after sunset must be adjusted using depression angles.[22] At a location much further north than the Middle East, this would require maintaining *Shabbat* for well over two hours after sunset (in the summer), as was the Rav's personal practice in Boston.[23] R. Willig's elegant and conceptually cogent formulation of the opinion of Rabbenu Tam was practiced only by isolated individuals; in the vast majority of cases, practice did not comport with the model.[24]

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19. See *Am Mordekhai*, *Berakhot*, chap. 2, particularly the end section on page 16, and *Am Mordekhai*, *Shabbat*, chap. 39, pp. 215-19.

20. Three small stars appear when the level of darkness reaches a requisite level, a particular depression angle. Whether darkness or three stars define the end of *Shabbat* is a largely theoretical dispute; practically, the times at which each occurs are very close to each other. Thus, depression angles correlate to both the degree of light and the appearance of stars.

21. In the summer in Vilna, at approximately 55 degrees north latitude, 72 minutes after sunset equates to a depression angle of less than 8.5 degrees. The seasonal variation in the length of time after sunset to reach a depression angle of 8.5 degrees is more than 40 minutes in Vilna, ranging from approximately 55 minutes in the spring and fall to 95 minutes in the summer.

22. The end of *Shabbat* would occur when the level of darkness equals that observed in the Middle East 72 minutes after sunset around either the spring or fall equinox, i.e. a depression angle of approximately 16 degrees. In the summer in Vilna, that level of darkness is never reached, leading some to suggest halakhic midnight as the end of *Shabbat*.

23. This was further lengthened because he, as well as his grandfather and others, assumed 90 rather than 72 minutes as the period of time needed to walk four *mil*. Despite the fact that 90 minutes, which equals 1/8th of the 720 minutes of a 12 hour daytime period, is the time endorsed by all *ḥakhmei Sefarad*, in the modern day, it is often called the "*Brisker akhtel*," *akhtel* meaning 1/8th in Yiddish.

24. A full discussion of this topic is well beyond the scope of this paper. However, it should be noted that common practice among those who maintained the position of Rabbenu Tam was to wait either exactly 72 minutes, or **less** than that. As far as I know, this was first mentioned quantitatively by R. Avraham Pimential in his seventeenth century *sefer, Minḥat Kohen*, and practiced widely thereafter; those following the opinion of Rabbenu Tam actually reduced his 72 minutes (often to around 50 minutes) based on the observation of three stars. See *Iggerot Mosheh O.Ḥ.* 4:62 for R. Feinstein's similar position regarding 50 minutes in the New York area. It is very plausible that R. Pimential was reflecting on how Rabbenu Tam's view was practiced, despite the conceptual difficulties

At the other end of the spectrum, after carefully explaining the views of modern *zemannim* calendars, R. Yisroel Reisman maintained a strong preference for an invariant 72 minutes over a 16 degree depression angle as defining the time of *alot ha-shaḥar*.[25]

To this day, the 72 minute nighttime opinion of Rabbenu Tam is normally applied uniformly, regardless of latitude or season, while use of depression angles for *alot ha-shaḥar*, and the resulting variation based on latitude and season, is currently debated.[26] However, the conclusion of *Shabbat* according to the *ge'onim* is (almost) always determined in a manner that equates to depression angles or its more traditional equivalent – the appearance of three stars.[27] From a scientific perspective, this is surprising; the need for depression angles should be more apparent with a larger angle (*alot ha-shaḥar*) than a smaller one (as at *ḥashekhah*).[28]

From everything I can determine, depression angles capture the *gemara's* notion of darkness and light, corresponding accurately to the events the *gemara* describes. No other mathematically precise alternative for "measuring" *ḥashekhah* or *alot ha-shaḥar* has ever been formulated, nor has anyone ever proposed any problem that depression angles might create. Clearly, we may not need such precision; observation was adequate for generations. *Nevertheless, a depression angle is to darkness/illumination what a clock is to time.* I know of no instance where depression angles would yield a different result than (careful) observation. The problem

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with this position, given Rabbenu Tam's equating the time interval between *alot ha-shaḥar and* sunrise and the interval between sunset and *ẓet ha-kokhavim*.

25. This was the practice of his *rebbi*, R. Avraham Yaakov Pam, as well as numerous other *posekim*. Rabbi Reisman's *shi'ur*, given on October 13, 2007, is titled: "A Dawn's Early Light."

26. According to the opinion of Rabbenu Tam, these points are identical and adjusting one and not the other makes no sense conceptually. For the *Ge'onim*, *alot ha-shaḥar* is unrelated to the transition point between days, the time that *Shabbat* ends.

27. Some calendars disguise their use of depression angles for the end of *Shabbat*, associating the times given for the end of *Shabbat* with medium/small *stars*, perhaps not wanting to create marketing problems by mentioning depression angles. At the other extreme, R. Yisroel Belsky, provides his approbation to the myzemanim.com website, which adjusts R. Moshe Feinstein's *pesakim* (which are season invariant) to conform to depression angles. They do this by assuming that the times that R. Feinstein provides are the maximum (applying only around the summer solstice) and are shorter during other times of the year.

28. For example, on May 1st, using depression angles of 8.5 and 16 degrees, *Shabbat* ends 39 minutes after sunset in Jerusalem and 58 minutes after sunset in London, while *alot ha-shaḥar* is 122 minutes before sunrise in London versus only 78 minutes in Jerusalem. The difference resulting from the larger depression angle is significant and the reason to adjust is yet more evident. Choosing a city further north than London (Vilna, for example) or a date closer to the summer solstice illustrates these phenomena yet more dramatically.

is that observation itself has been replaced by a clock—and depression angle measurements conflict with clock measurements, which are used to set *zemannim* at a precise number of minutes before or after a particular event like sunrise or sunset, as will now be elaborated.

Clocks

While clocks existed in antiquity, they qualify as a more recent technological innovation because their widespread use began only in the fifteenth century. Their availability in Northern Europe was certainly rare or non-existent during most of the period of the *rishonim*. Clocks had a seductive influence in reducing reliance on observation, perhaps even introducing a (questionable) sense of certainty. For example, this paper assumes that *alot ha-shaḥar* correlates with the first light of day, however that may be precisely defined. Four common clock based surrogates for *alot ha-shaḥar* are:

> 1) a fixed 72 minutes before sunrise,
> 2) a fixed 90 minutes before sunrise,
> 3) a varying 72 minutes before sunrise based on the length of the day from sunrise to sunset, longer in the summer and shorter in the winter, and
> 4) a varying 90 minutes before sunrise based on the length of the day from sunrise to sunset, longer in the summer and shorter in the winter.

None of those four alternatives coincides with observation.[29] While the appearance of the first light of day clearly varies by latitude and season, the last two methods, which assume that the length of the twilight period varies with the length of the day, are even more acutely at variance with reality.[30] All are likely to have gained prominence as clocks reduced

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29. By observation, an interval of 72/90 minutes only applies around the spring and fall equinox and only at the latitude of the Middle East. Commentators limit the *sugya* in *Pesaḥim* 94a (from which 72/90 minutes is derived) to the days around the equinox, as it assumes a twelve hour day. The limitation to latitudes of the Middle East requires an appreciation of the impact of latitude; that impact was not mentioned by early commentators, and was first discussed at length by R. Pimential in *Minḥat Kohen*.

30. Both observation and scientific theory assert that dawn precedes sunrise by a *longer* interval in the winter than in the fall or spring. The latter two approaches do not account accurately for the combined impacts of season of the year and latitude. First, even in the Middle East, where latitude is not an issue, and where using 72/90 minutes as the base for *alot ha-shaḥar* around the spring and fall equinox on a 12 hour day is accurate, correlating the period between *alot ha-shaḥar* and sunrise with the duration of the sunrise to sunset daytime period is directionally correct in the summer although inaccurate computationally and entirely incorrect in the winter. As the days get shorter

the need for observation. Rambam in his commentary to the Mishnah (*Berakhot* 1:1) mentions 1 and 1/5th hours. Normally, however, a less precise "period of time needed to walk four *mil*" is cited. Before widespread use of clocks, observation was required; clocks and the accuracy they provided made observation less necessary. Observation is unlikely to have produced either a non-seasonally and certainly not a non-latitude adjusted interval or an interval whose variance is inconsistent with actual seasonal variation.[31]

These alternative views on *alot ha-shaḥar* are good examples of the likely consequences of clocks. Nevertheless, because this particular issue is a practical halakhic matter that is broadly disputed and of widespread consequence, it would require a longer and more detailed analysis than I can undertake here. Instead, we will examine a different illustration of the probable impact of clocks, one that is more intriguing, albeit of lesser consequence: the calculation of *zemannai ha-yom* according to what is commonly referred to as the opinion of Magen Avraham.[32]

The calendar of Jerusalem was heatedly debated slightly over a century ago.[33] For our purposes, I will simplify the history. At that time, the calendar defined the length of a day using *alot ha-shaḥar* together with the normal end time for the days of the week (to be defined shortly). The calendar was used to calculate all the *zemannim* of the day, implementing the opinion of Magen Avraham. This view had clear precedent in many major European cities where prominent rabbinic authorities were the halakhic decisors.[34] In any case, the young R. Tukitzinsky approached his wife's grandfather, the venerable R. Shmuel Salant, with the following problem: the calendar is miscalculating an observable point of

in the winter, the length of the twilight period actually increases. (*Posekim* likely had some hesitation with this conceptual approach that would shorten the twilight period, as many asserted that one should not use the leniencies that derive in the winter months.) Second, at latitudes other than the Middle East, the base of 72/90 minutes must be adjusted by latitude even on a twelve hour day.

31. This linear correlation was (first) proposed by R. Pimential (see *Minḥat Kohen, ma'amar* 2, chap. 5) when he generalized a relationship between the length of the day and a (particular) twilight period (1/15th of a day) from two observations that he fit to a straight line. Since the relationship is non-linear, that extrapolation was incorrect. It is unclear whether he meant this to apply generally. Unlike some *posekim* who followed him, he was troubled by a shorter twilight period in the Netherlands, further from the equator than the Middle East. (His solution, ascribing a 24 minute discrepancy to elevation, was incorrect.)

32. Earlier sources (see for example the chapter headings in *Minḥat Kohen)* attribute the position we refer to as Magen Avraham's to R. Israel Isserlein; it can be traced to Ramban and perhaps even earlier.

33. See Benish, 1:114-18.

34. See multiple examples in Benish, 1:118-19, 2: 258-59.

ḥaẓẓot, viz., the midday point when the sun would be directly overhead. That fact should be both observable and provable since the time between *alot ha-shaḥar* and sunrise (the time the sun travels 16 degrees) is significantly longer than the interval between sunset and the end of the day (the time the sun travels only 8.5 degrees.)[35] If sunrise and sunset are at 6:00 AM and 6:00 PM respectively, and *alot ha-shaḥar* was at 4:40 AM, and three stars are visible at 6:30 PM, then *ḥaẓẓot* would be calculated at 11:35 AM, a full 25 minutes too early. R. Yosef Ḥayyim Sonnenfeld, adopting an expected traditional stance,[36] was neither able to resolve the problem nor accept the proposed change that would, as we will see, add a few minutes to *sof zeman keri'at shema*. Therefore, it remained unchanged for another few years, until R. Yiẓḥak Goldberg of Minsk visited Jerusalem and strongly supported the position of R. Tukitzinsky. R. Tukitzinsky then created an astronomically compliant calendar, supported by the *gemara* in *Pesaḥim* 94a.[37] What he did to establish the revised calendar of Jerusalem was to utilize the time the Gaon defined as the nighttime equivalent of *alot ha-shaḥar*, a point the Gaon referred to as *ẓet **kol** ha-kokhavim*,[38]

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35. R. Tukitzinsky would have recognized that both by his meticulous observation and his knowledge of astronomy.

36. A ruling of R. Sonnenfeld adds a sense of balance and consistency to the view that some might otherwise presume about this prominent *ḥaredi* authority. It provides a remarkable reminder of a past that focused on traditional community practices. The *ḥevra kadisha* of Jerusalem wanted to attend to a decedent 40 minutes after sunset. R. Sonnenfeld, contrary to the wishes of the family, ruled that the *ḥevra kadisha* can attend to the body at that time—even though both R. Sonnenfeld and the deceased customarily waited 72 minutes after sunset for the end of *Shabbat*. Later that afternoon, news of a second death caused the widow to suggest that the second man can now be tended to first, which would leave her late husband untouched until well after 72 minutes following sunset. R. Sonnenfeld insisted that the *ḥevra kadisha* work in their normal order, tending first to her husband, who died earlier. His logic was that even when personal stringencies (72 minutes) conflict with the community's traditional practice (the equivalent of an 8.5 degree depression angle or about 40 minutes), the latter is overriding.

37. That *gemara in Pesaḥim* asserts an equal period of twilight in the morning and evening. It is possible to treat this *sugya* as only theoretical, without necessarily specifying a position on how hours of a day are to be calculated even for those who compute from *alot ha-shaḥar*. However, Ramban and the many *ḥakhmei Sefarad* who declare that *pelag ha-minḥah* occurs at the period of time needed to walk 1/6th of a *mil* prior to sunset used this *sugya* as a basis for computation; their views support R. Tukitzinsky's method of calculation explicitly. If Ramban and others were using an earlier point like *ḥashekhah* / three small stars, then *pelag ha-minḥah* would occur well before sunset.

38. The Vilna Gaon (*O.Ḥ.* 459) associated no halakhic significance with *ẓet kol ha-kokhavim*, as opposed to three stars, as it indeed is not needed in his system; he calculated *sha'ot zemanniyyot* from sunrise to sunset. Assuming that *ẓet kol ha-kokhavim* has no halakhic significance beyond its use in the calculation of the times of Magen Avraham adds credence to the alternative to be proposed below. In the last century, a number of Brisker conceptual talmudists have hypothesized significance for *ẓet **kol** ha-kokhavim,* differentiating the end of the day, three stars, (*ẓet ha-kokhavim*), from the end of the daytime period (*ẓet **kol** ha-kokhavim*).

which occurs when the sun is again 16 degrees below the horizon.[39] If *alot ha-shaḥar* occurred 80 minutes before sunrise, then *ẓet kol ha-kokhavim* would occur 80 minutes after sunset. Using those endpoints, *ḥaẓẓot* would be calculated at the astronomically observed point as opposed to some number of minutes earlier. This calendar is used primarily for morning *zemannim*, but rarely for *zemannim* in the afternoon.[40]

I cannot attribute this miscalculation of *ḥaẓẓot* entirely to clocks. However, consider the practice required before clocks and long arithmetic enabled a precise calculation of *sha'ot zemanniyyot*. Here is a scenario to consider that is consistent with the oft quoted verse in Neḥemiah (4:15) specifying the daytime period: "*Va-anaḥnu osim ba-melakhah . . . me-alot ha-shaḥar ad ẓet ha-kokhavim*," "We worked . . . from *alot ha-shaḥar* until *ẓet ha-kokhavim*." As interpreted explicitly by the *Yerushalmi* at the beginning of *Berakhot* and by many commentators, including Rabbenu Tam and some of his followers, the daytime period defined by the verse is, by observation, asymmetric with respect to sunrise and sunset.[41] It also may be the antecedent of what became the calendar of Jerusalem and other cities. The beginning and end of the day specified in the verse are interpreted as *alot ha-shaḥar* and three stars respectively, the endpoints used by many calendars like the one of Jerusalem that R. Tukitzinsky attacked.

Without a doubt, Ramban[42] defined the hours of the day by what centuries later was called the opinion of Magen Avraham. It is absolutely clear as well that the process of calculation that Ramban endorsed divided the period between *alot ha-shaḥar* and its evening equivalent[43] into

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39. The view of the Gaon is broadly disputed; those who assert that he concluded that the period of time needed to walk a *mil* was 22.5 minutes would change the period of time needed to walk four *mil* from 72 to 90 minutes and change the associated depression angles from 16 to 20 degrees.

40. None of the opinions of Magen Avraham are commonly used in setting afternoon *zemannim,* particularly at the more northern latitudes of the United States and Europe.

41. Those who followed Rabbenu Tam equated the appearance of three stars with the end of the period of time after sunset needed to walk four *mil*. Nonetheless, many of those authorities used the appearance of three stars (with various stringencies), without regard to the number of minutes after sunset when stars appeared. This was, in a certain sense, implicit in the Gaon's rejection of Rabbenu Tam, who treated three stars and *alot ha-shaḥar* as symmetric. The Gaon deemed this assumption factually incorrect and contradicted by observation. Discussions of stars were common among *rishonim* as well as in the *pesakim* of R. Pimental, R. Sofer, and R. Feinstein, referenced in notes 24 and 63, to name just three *posekim*. The above authorities all focus on the appearance of stars instead of just the period of time needed to walk four *mil.*

42. *Torat ha-Adam*, in *Kitvei ha-Ramban*, ed. C. B. Chavel (Jerusalem, 1964), 2:251–55.

43. The point when "all the stars," as opposed to only three stars, are visible.

twelve parts to derive the length of an hour.[44] However, despite the theory articulated by Ramban, the practical process even for those who followed Rabbenu Tam[45] may have been implemented differently before the era of clocks. I would conjecture that:

– *Ḥaẓẓot* was not calculated; time was estimated by angles that were approximated from the high point in the sky (equal to *ḥaẓẓot*) to a point in the morning and the evening.[46]

– The evening point was set not by the Vilna Gaon's notion of *ẓet kol ha-kokhavim*[47] but by the appearance of three stars, which was assumed by a significant number of *rishonim* to occur the same length of time after sunset as *alot ha-shaḥar* occurred before sunrise.

To be concrete, assume that sunrise and sunset are at 6 AM and 8 PM. Assume further for computational simplicity that *alot ha-shaḥar* is observed at 4:40 AM and three stars are observed at 8:40 PM, with the evening counterpart of *alot ha-shaḥar, ẓet kol ha-kokhavim* occurring at 9:20 PM. Taking the midpoint between 4:40 AM and 9:20 PM, *ḥaẓẓot* can be calculated and also observed at exactly 1 PM, with *sof zeman keri'at shema* occurring at 8:50 AM. However, using the calendars of old we would compute *ḥaẓẓot* at 12:40 PM, off by 20 minutes—which is the problem

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44. That is derivable from Ramban's assertion that *pelag ha-minḥah* occurs at the time it takes to walk 1/6th of a *mil* before sunset. I cite Ramban because, as noted, the *gemara* in *Pesaḥim* 94a itself can be interpreted as not necessarily providing a normative opinion to be used in calculating *zemannim;* Ramban unquestionably does.

45. The followers of Rabbenu Tam include many *rishonim*, *Shulḥan Arukh*, and all its major commentators until the middle of the eighteenth century. From then on the opinion of the *Ge'onim* began to gain more adherents.

46. See Ravyah, vol. 2, p. 64, who, as I read his words, used *ḥaẓẓot* as an anchor for his approximations for *zemannim*.

47. *Ẓet kol ha-kokhavim* as the counterpoint to *alot ha-shaḥar* is a logical consequence of Rabbenu Tam's position, particularly as formulated by Ramban. *Ẓet kol ha-kokhavim* as the position of Rabbenu Tam was formulated even more profoundly in R. Soloveitchik's *yahrzeit shiur* titled "*Yom va-Laylah*," in *Shiurim le-Zekher Abba Mori z"l* (Jerusalem, 2002), 107–27. However, despite the compelling logic behind *ẓet kol ha-kokhavim* and support derivable from the position of Ramban, I have found no historical reference to its ever being used *in practice* prior to recent times. The Gaon used it only to explain the difference between the *sugyot* in *Pesaḥim* and *Shabbat,* without ascribing to it any practical halakhic significance. In fact, as noted, many *posekim* who claimed to follow Rabbenu Tam used the appearance of three (adjacent) stars as defining the end of *Shabbat*, well before even 72 minutes and certainly before *ẓet kol ha-kokhavim*, despite the fact that it does not comport with Rabbenu Tam's conceptual position. This dissonance between concept and practice is one of the most difficult issues in the entire area of *zemannim*. While making this change from *ẓet kol ha-kokhavim* to three stars in the opinion of Rabbenu Tam is challenging conceptually, it does not create such challenges with respect to calculating the hours of the day.

R. Tukitzinsky raised.[48] Assume now that we have no precise clocks and known times and we need to observe the hours of the day. It is hardly likely that we would calculate *ḥaẓẓot;* we would simply assume it occurs when the sun is directly overhead. The morning hours would be calculated/ approximated between *alot ha-shaḥar* and *ḥaẓẓot,* the afternoon hours between *ḥaẓẓot* and the appearance of three stars. Of course, those who are mathematically oriented will immediately note that afternoon hours are (slightly) shorter than morning hours.[49] As surprising as that may be, it is not contradicted by any principle I have ever found in *zemannim*[50] and is certainly less troublesome than miscalculating *ḥaẓẓot.*[51] My suspicion is that this may have been the practice used for approximation before widespread use of clocks; it is the only methodology that uses non-equidistant endpoints for calculation without deriving an inaccurate point for *ḥaẓẓot.* With the invention of clocks it may have naturally morphed into a calculation from *alot ha-shaḥar* to the appearance of three stars, creating uniform hours throughout the daytime but a miscalculated point of *ḥaẓẓot.*

Posekim maintained the traditional endpoints of *alot ha-shaḥar* and three stars, but their use of a new method of calculation led to issues with *ḥaẓẓot.* The approach adopted in Jerusalem maintained the method of calculation but changed the endpoints; what I am suggesting maintains the endpoints but changes the method of calculation. Were this argument adopted, *posekim* could reestablish the use of the traditional endpoints of *alot ha-shaḥar* and three stars by taking *ḥaẓẓot* as observed and then establishing both morning and afternoon *zemannim* by calculating from midday to *alot ha-shaḥar* and three stars respectively.[52]

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48. *Sof zeman keri'at shema*, which is halfway between *alot ha-shaḥar* at 4:40 AM and *ḥaẓẓot* at 12:40 PM, occurs at 8:40 AM, ten minutes earlier than when using R. Tukitzinsky's calculation.

49. Assuming *alot ha-shaḥar* is 80 minutes before sunrise and three stars appear 40 minutes after sunset, then the six morning hours would be (40/6=) 6 and 2/3rd minutes longer than the six afternoon hours, 73 and 1/3rd minutes versus 66 and 2/3rd minutes.

50. R. Feinstein in *Iggerot Mosheh O.Ḥ.* 1:24 and *Iggerot Mosheh O.Ḥ.* 2:20, for different reasons and in conjunction with his view that *ḥaẓẓot* is always at the same time at a given location (see note 56), writes "*she-shenei ḥaẓa'ei ha-yom einam shavim.*" Despite the fact that I do not know his rationale, his view is nonetheless supportive.

51. See for example, *Minḥat Yiẓḥak* 4:53, where R. Weiss asserts that any approach that does not calculate *ḥaẓẓot* accurately is untenable.

52. The approach of R. Tukitzinsky and the one suggested are identical with respect to the morning *zemannim,* but differ significantly with respect to all afternoon *zemannim.* Both approaches, however, happen to create a practical time for *pelag ha-minḥah* in the New York area for those wishing to *daven* early in the summer, but with *minḥah* and *ma'ariv* before and after *pelag ha-minḥah*, respectively. I leave the verification as an exercise for the reader.

Personally, I find the calendar of R. Yeḥiel Mikhel Tukitzinsky most compelling,[53] but I strongly suspect that a calendar that uses three stars versus *ẓet kol ha-kokhavim* may be more consistent with tradition from at least the sixteenth to nineteenth century and perhaps even in antiquity.[54] In any case, clocks may have altered the method of calculation for *zemannei ha-yom,* as well as created a simplified version of the position of Magen Avraham, often referred to as Magen Avraham *ke-nahug*.[55] I would guess that the reason the proposed explanation of the more traditional approach was never put forward is that, in the century since the problem was identified, we appear to have all been fixated on clocks and long arithmetic; the thought of not calculating *ḥaẓẓot* still appears unnatural.[56]

A careful reader will also note that the latter two opinions, that of R. Tukitzinsky and the one I suggest, produce two additional opinions, by replacing 72 minutes with 90 minutes. The use of 90 minutes is, in fact, the custom of Jerusalem and the clear position of Ramban, a point I will set aside. In a forthcoming paper on *Sha'ot ha-Yom*, I hope to illustrate that the approach of R. Tukitzinsky to Magen Avraham and the use of 90 versus 72 minutes, both part of the established *minhag* of Jerusalem, create some anomalies when computing *pelag ha-minḥah* during certain seasons of the year. Both the method employed previously in Jerusalem that R. Tukitzinsky successfully opposed, and one using an observed *ḥaẓẓot* and an earlier point of three stars versus *ẓet kol ha-kokhavim*, avoid this issue.

53. It is a more mathematically appealing computation, and more importantly, consistent with the formulation of Ramban in *Torat ha-Adam* and *ḥakhmei Sefarad* who followed his approach.

54. There are a number of challenges to the opinion of Magen Avraham and some earlier adherents of his position that this approach would address. We will detail these challenges and that referenced in note 52 in a paper on *Sha'ot ha-Yom* that deals extensively with the opinion of Magen Avraham.

55. Magen Avraham *ke-nahug* typically calculates from a fixed 72 minutes before sunset to a fixed 72 minutes after sunset. To the best of my knowledge, although Magen Avraham *ke-nahug* is often used in setting *zemmanim* in the morning, it is never used to set *zemmanim* in the afternoon. In addition to a fixed 72 minutes, each of the other three alternatives for calculating *alot ha-shaḥar* that were previously associated with the introduction of clocks create an associated method for calculating according to the position of Magen Avraham. The issues raised with respect to those four alternatives for *alot ha-shaḥar* apply to calculating according to the position of Magen Avraham, as well.

56. R. Moshe Feinstein's position (*Iggerot Mosheh O.Ḥ.* 2:20) is that *ḥaẓẓot* is always at the same time and is not calculated but observed, a practice that he asserts without detailed explanation and attributes to his father. Astronomically, in the New York area, *ḥaẓẓot* varies during the year by approximately 20 minutes. I strongly suspect that his position is somehow related to this approach where *ḥaẓẓot* was not calculated but observed, a phrase R. Feinstein employs—*she-hu ke-she-ba ha-shemesh le-emẓa ha-darom*. It is also plausible that the difficult position of R. Shlomo Zalman Auerbach (*Minḥat Shelomoh* 1:91 and 2:58) on the nighttime point of *ḥaẓẓot*, which deviates as well from the precise astronomical point, derives from this type of approach. It is ironic that both of these recognized *posekim* would maintain unexplained positions on *ḥaẓẓot*. At the very least this approach might provide a point from which both positions may have originated.

Clocks, as well as the calculations they enabled, may have provided a level of precision that is neither accurate halakhically nor in consonance with (traditional) observance or observation.

Minutes after Sunset

The three previous examples all involve something of an innovation, an artifact like the clock or a new concept like the dateline or depression angles. The final example represents a gradual change over a long period of time in colloquial manners of expression. Consider two near contemporaries, R. Nosson Adler and R. Yaakov Lorberbaum. R. Adler's period of *bein ha-shemashot*, as quoted in an addendum at the end of *massekhet Pesaḥim* in the *ḥiddushim* of his student, R. Mosheh Sofer, is between 24 and 35 minutes. Shnayer Z. Leiman, in a taped lecture,[57] told the history of how this line was deleted in an edition of the Ḥatam Sofer's *ḥiddushim* published by Satmar Ḥasidim after the Second World War. As Leiman explained, they did not want to acknowledge that R. Adler maintained so early an end to *Shabbat*, one they assumed was at most 35 minutes after sunset.[58] There have been many attempts to explain this remark of R. Adler.

Similarly, the section of R. Lorberbaum's *Derekh ha-Ḥayyim* about the start of *Shabbat* has been amended with the original numbers assumed to be incorrect.[59] What R. Lorberbaum was specifying was (A) the absolutely latest point to start *Shabbat* (after which one could not light candles, for example), which occurs 37.5 minutes after sunset; as well as (B) the earliest point when one can accept *Shabbat* by an action (lighting candles, for example) without an explicit declaration, which occurs 57 minutes earlier or about 20 minutes before sunset. Two revisions have been suggested: 1.5 minutes replacing 37.5 minutes and 58.5 minutes replacing 57 minutes. R. Lorberbaum used ¼ hour as an approximation for the period of time needed to walk ¾ *mil* or 13.5 minutes, extending that time slightly to account for *tosefet Shabbat*. The change to 1.5 minutes

57. "Jewish Censorship in Literature in Modern Times," recorded 05/12/99.

58. It is unclear whether Prof. Leiman is criticizing the interpretation or acknowledging its correctness and only criticizing the audacity of its censorship. The latter appears more reflective of his tone.

59. See for example, the edition of *Derekh ha-Ḥayyim* published by Asher Gartner (Bnei Brak, 5747), 76-77. In 2006, R. Reuven Bulka and his sister Rebecca (Bulka) Rivkin, republished the "Bulka *siddur*" in memory of their parents and distributed it at a grandchild's Bar Mitzvah. Originally published by their grandfather in Nuremburg in 1925, it contains an earlier text of *Derekh ha-Ḥayyim*. *Derekh ha-Ḥayyim* was often reprinted in *siddurim*.

reflects the difference between 13.5 minutes and ¼ of an hour. It is easier to reconcile 58.5 minutes[60] with the remainder of the text than 1.5 minutes; 58.5 minutes is the standard [61] opinion of Rabbenu Tam for when *bein ha-shemashot* begins—the length of time *after* sunset to walk 3.25 *mil* is (3.25 x 18 =) 58.5 minutes.

Both changes result from a failure to realize both R. Lorberbaum's linguistic construct and his halakhic position. In fact, and this is what was likely missed by those proposing an emendation, 37.5 minutes is ¾ of a *mil* (13.5 minutes) or 15 minutes prior to the end of *Shabbat – counting backwards* from the time that *Shabbat* is likely to have ended at that location.[62] As well, 57 minutes + ¼ hour equals 72 minutes, (as would 58.5 + 13.5 minutes,) counting backwards from the end of *Shabbat* (51 – 53 minutes after sunset) to a point approximately 20 minutes before sunset.

This simple observation partially explains R. Adler's position as well. In common parlance, we say: "*Shabbat* is over X minutes after sunset." For reasons that would require a significant and speculative digression, we tend to count forward (and backward) from sunset. In many contexts, the two cited above being perfect examples, more traditional usage often counts back from *ḥashekhah*, the end of *Shabbat*, rather than only forward from sunset. R. Adler meant that *Shabbat* starts 24-35 minutes before it ends a day later at *ḥashekhah*, not that it ends 24-35 minutes after sunset.[63] Our tendency to count forward from sunset should not

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60. Note that either 15 + 57, following the language in the original text, or 13.5 + 58.5, following the suggested emendation, both equal 72; the change is not as fundamental.

61. Again using 72, versus 90, minutes, as the period of time needed to walk four *mil* (the opinion of the *Shulḥan Arukh*).

62. Approximately 51-53 minutes as elaborated in the next note. Clearly, R. Lorberbaum was following a modified version of Rabbenu Tam, similar to R. Pimential as discussed in note 24.

63. Though the point is not directly relevant to this discussion, R. Adler was possibly using (approximately) 72 minutes after sunset as the point from which he was counting back, while R. Lorberbaum was counting back from the practiced end of *Shabbat* in the locale for which he was writing, approximately 51- 53 minutes after sunset. The conceptual rationale for either approach is not provided and is not covered in this paper. While I cannot fully explain the conceptual basis for R. Adler's position, only an approach where he is counting back from some later time than the end of *Shabbat* in Frankfurt can be reconciled with *She'elot u-Teshuvot Ḥatam Sofer* #80, concerning a baby born on *Shabbat* approximately 27 minutes after sunset. While he may disagree with R. Adler in many aspects concerning the end of *Shabbat* and the *bein ha-shemashot* period, I assume that R. Sofer would not dismiss his *Rebbi's* approach where a possible *ḥillul Shabbat* at a biblical level would be involved. If, however, R. Adler was subtracting from 72 minutes, then 35 minutes earlier would also be 37 minutes after sunset, remarkably consistent with R. Lorberbaum and consistent with the later *pesak* of R. Sofer. Any other plausible interpretation of R. Adler places R. Sofer's *pesak* in conflict with R. Adler.

be assumed when reading the halakhic literature. Common modes of expression create assumptions that we then use as we attempt to read non-contemporary texts; both R. Adler and R. Lorberbaum[64] were using a more classical mode of expression. It is plausible that presuming counting forward from sunset as opposed to also considering counting back from *ḥashekhah* may relate to the increased prominence of sunset in both halakhic and secular contexts.[65]

Concluding Remarks

New paradigms, including something as simple as a widely reported point of sunset,[66] can have subtle impact of how Halakhah is expressed. With some reservations, I will outline some rudimentary conclusions, extrapolating from the four examples.

   One could argue that clocks, depression angles, datelines and perhaps sunset as well all have an aura of precision that might be intuitively appealing—but overly valued. One ought to ask whether a particular precise notion is a more exact analogue of a previously used notion or whether the precise notion differs in some relevant detail. Certainly, those cases

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(Latitudes for all three cities, Frankfurt, Zolkiev and Pressburg, for which *zemannim* were given by the three *posekim* are within approximately 2 degrees of each other, with Pressburg furthest south. It appears that all three cities ended *Shabbat* approximately 52 minutes after sunset, at least in the summer. Frankfurt started *Shabbat* at sunset; the other two cities apparently did not.) Some more recent attempts to reinterpret R. Sofer are beyond the scope of this paper and, in any case, difficult to maintain both historically and conceptually. Regardless of exactly what point was the anchor, it is clear that R. Adler was counting back from some point of *ḥashekhah*, not forward from sunset or some other point.

64. Shlomo Sternberg makes the point about R. Lorberbaum in passing in an article available at his Harvard website, http://www.math.harvard.edu/~shlomo/docs/beinhashemashot.pdf.

65. The identification of sunset as the precise beginning of *bein ha-shemashot* has become almost universal. It is noteworthy, however, that not all *posekim* through the generations have concurred with this identification. Aside from Rabbenu Tam's opinion mentioned in notes 41 and 47, see: R. Chaim Volozhiner's view, as reported in the *hosafot* (additions) to *Ma'aseh Rav*, section 19; the views reported in R. Yaakov Gliss, *Minhagei Ereẓ Yisrael*, (Jerusalem, 1968), 102, 282; R. Meir Posen, *Or Me'ir* (London, 1973); Rambam, *Mishneh Torah*, *Hilkhot Shabbat* 5: 3,4 and *Hilkhot Kiddush ha-Ḥodesh* 2:8,9, as explicated by R. Yosef Kapaḥ in his commentary to *Mishneh Torah*; R. Moshe Feinstein, *Iggerot Mosheh*, *O.Ḥ.* 4:62.

66. The precise definition of sunset implicitly includes a notion of sea-level, a topic that has received recent attention. Not surprisingly, Ḥazon Ish could find no early source to deal with some of the complexities of sea-level.

where no prior analogue exists must be carefully examined.[67] It would be difficult to argue that depression angles have no talmudic analogue.[68] At best one could try to argue that depression angles are in some way not a precise formulation of what the various *sugyot* were trying to express. Frankly, I have not seen such an argument, nor can I think of how it would proceed. Contrast this with datelines, where I have never seen reference to any talmudic source that discusses anything remotely similar, save the interpretation of R. Zeraḥyah ha-Levi.[69]

Clocks, like depression angles, also provide precision for a well established halakhic concept. However, the popularity of clocks and the comforting sense of exactitude they provided likely morphed from just adding accuracy to observation to replacing the need for observation *in toto*.[70] At least in popular culture, and I would argue on occasion in *pesak* as well, measured time replaced astronomical events as the underlying definition of a particular *zeman*.[71] Furthermore, the issue with clocks involves perhaps not just (unwarranted) dependence on time as the defining concept, as for example in the significance that 72 minutes holds for many in actually defining as opposed to approximating *alot ha-shaḥar*, but its use in defining halakhic processes as well. The precision that clocks provide may have facilitated change to a halakhic calculation that resulted in complexities vis-à-vis determining *sha'ot zemanniyyot* represented by calculating an inaccurate point of *ḥaẓẓot*. Clocks may have made approximation unnecessary only to be replaced by a precise, albeit flawed method of calculation, when using non-equivalent endpoints.

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67. Of course, one can argue similarly about any new conceptual category created. This is particularly relevant given the dominance of a modern conceptual methodology in the study of Talmud. For example, in an area we noted earlier concerning any halakhic significance to *ẓet kol ha-kokhavim*, modern adherents of the Brisker methodology distinguish between the "day of the week" that ends with *ḥashekhah*, approximately *ẓet ha-kokhavim* (the appearance of three stars), and the "daytime period" that perhaps extends until *all* the stars are visible, *ẓet kol ha-kokhavim*. They can then hypothesize cases where *ẓet **kol** ha-kokhavim* versus *ẓet ha-kokhavim* would (or should) have practical significance. Support for such a position from traditional sources is limited at best.

68. Terms like *ḥashekhah* and *mi-she-yakkir* measure levels of darkness. The *gemara*'s description of *ovei ha-rakia* (*Pesaḥim* 94a) is remarkably similar to depression angles, a point that R. Hoffmann takes even a step further in *Melammed le-Ho'il*, #30.

69. This was a major point of contention between many *posekim* and Ḥazon Ish.

70. A somewhat related and more conceptual point concerning not clocks but time in general is argued with multiple examples by Sacha Stern in *Time and Process in Ancient Judaism* (Oxford, England and Portland, Oregon, 2003), chapter 2.

71. The classical disagreement centers on whether the appearance of stars or a requisite level of darkness (or equivalently the appearance of the sky), not time, define the end of *Shabbat*. Similarly, physical phenomena are the basis for defining almost all *zemannim*.

Thus, an important question applicable to both the clock and the dateline is how the process of determination might have been executed in antiquity. Absent a clock or a dateline, one can easily conceive of an alternate methodology to address the question, providing not just a less precise answer, but one that also differs in some critical aspect.

In summary, the halakhic impact of datelines, depression angles, clocks and sunset each requires its own detailed analysis. While the "modern" issues around datelines and depression angles have received adequate halakhic attention, more complex issues surrounding clocks, whose history stretches back half a millennium and beyond, and sunset require more study. Of interest in many of these cases is the tension be-tween using modern developments in science and technology to render halakhic concepts more precise, and relying on more traditional modes of observation, approximation and/or decision making.

My own leanings in each of the areas are clear. I remain skeptical about the need for and the validity of a dateline, and I believe strongly that depression angles capture accurately the halakhic notions of light and darkness. Clocks had significant effect, at times weakening a tradi-tion that relied on approximations based on observation; definitions de-pending on observation may have been partially obscured and replaced by focusing on a fixed amount of time and related calculations. Perhaps those traditional definitions will be reestablished and defined for poster-ity using depression angles, as they are increasingly being adopted (even) within very traditional circles. Depression angles may bring us full circle to the equivalent of classic dependence on observed events rather than on clocks, creating not just clock-like precision but observation-con-forming accuracy.