

## *Methodologies Used by Poskim to Determine the Orientation of the Synagogue*

By: ARYEH SHORE

The *poskim* of the 16<sup>th</sup> to 19<sup>th</sup> centuries made use of the available scientific literature to determine the halachah. In the field of animal science this included performing experiments, using books of natural history and surveys.<sup>1</sup> The present paper discusses the methodology and sources used by the *poskim* for determining the direction of prayer towards Yerushalayim. Three methods are considered: camera obscura, the “great circle” and the compass.

The halachic discussion of why the synagogues in northern Europe faced east, in spite of the decisions of the *Lavush*, *Taz* and *Mishnah Berurah*<sup>2</sup> to pray to the southeast, have been summarized

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<sup>1</sup> Aryeh Shore. “The role of animal dissections in determining Jewish Law” BDD (*Bekal DarKekha Da’ebu*, Bar Ilan Univ. 1997 4:73-80; “Identification of the first-born calf” *Halichot Sadeh* 1997, 104: 51-55; “The use of scientific sources by rabbinical authorities to determine the nature of animal species” *Korot* (Heb. Univ.) 12 (1996-1997): 7-15; Laurence S. Shore. “Efforts by Jewish communities to prevent zoonoses” *Torah U’Maddab* 8 (1998-1999): 277-282. For example, in the 1700s there was a debate regarding the permissibility of a chicken with no visible heart. After R’ Tzvi Ashkenazi, the *Chacham Tzvi*, appealed to experiments done by Galen to prove his point, R’ Yonatan Eybeshutz consulted with the Halle Academy of Medicine (see *Chacham Tzvi* 74-78; *Kreiti Upleiti* 40:4).

<sup>2</sup> *Lavush*, Perek Techelet, *Hilchot Tefillah* OH 94; *Mishneh Brurah* OH 94.

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by *Aruch HaShulchan*.<sup>3</sup> Briefly, the *Aruch HaShulchan* is apologetic as to why the European synagogues do not face southeast but states that the intent of Talmudic texts is that just the general direction of Eretz Yisrael is required.

The Jews of France and Germany had no problem in facing east as the general direction of Yerushalaim (*Tur* OH 94). As the Jews moved to more northern climes, the inconsistency of praying toward the east when Yerushalayim is in the southeast became more of a concern, especially since the Christian churches were oriented to the sunrise and deliberately orienting the synagogue to the east appeared to violate the injunction in the *Gemara* not to pray to the east as the idol worshippers do.

The first mention of the problem is by Rabbi Yeshayah ben Eliyah di Trani (d. c. 1280) brought in the *Shiltei Giborim* (*Hagaot Alfasi HaChadashim*).<sup>4</sup>

“This is what the ancients meant that one does not pray in the synagogues directly against the sunrise. In our synagogues, we pray toward the middle of the day.” It would seem that the middle of the day would be south, as in all places north of Israel in Europe and Asia, the sun is in the south at noon. However, the *Mishnah Berurah* says that this isn’t meant to be literal but just that one should face southeast. Alternatively, the middle of the day is referring to determining east by using the position of the sun at midday to determine true north and south and then turning to the east.<sup>5</sup>

### Camera Obscura

A camera obscura or pinhole camera is a room or box where the sun shining through a small window or hole can be used to determine direction and the meridian. The most influential description of using a camera obscura is that of Mordechai Yaffe in *Lavush* OH 94 published in 1590 as his description was brought by the *Taz* and the *Divrei Chamadot*. However, the drawings from the early edi-

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<sup>3</sup> *Orach Chaim* 94; *Berachot* 30a; *Bava Batra* 25b; *Y. Berachot* 8.

<sup>4</sup> *Berachot* 23b (*Talmud Bavli*, Lemberg 1860).

<sup>5</sup> Yom-Tov Lipmann ben Nathan ha-Levi Heller, *Divrei Chamadot* on the Rosh 19, *siman* 66; 1628.

tions of the *Lavush* (Fig. 1 א, ב, ג, ד), did not appear in later additions. The *Taz* does have a drawing (Fig. 2) in early editions, but in modern editions it is an incomprehensible composition of lines (Fig. 3).

While some thought the correction of the *Lavush* was an outstanding contribution to rational thought in the halachah (“Schon R. Mordechai Jafe hat dies ges suhlt und eine sudwestliche Richtung der Synagogen empfohlen.”),<sup>6</sup> the drawings of the *Lavush* apparently were confusing to some, and according to a question asked of R. Eliyahu bar Shmuel from Lublin<sup>7</sup> this resulted in a synagogue with totally incorrect orientation, depicted in Fig. 4. R. Eliyahu states that the coordinates for Yerushalayim given in *Chukat HaShamayin*, p. 137, by R. Y. from Candia (Crete) (*Sefer Elim* by Joseph Solomon Delmedigo; 1629) calculated using spherical geometry<sup>8</sup> would be the best method to determine direction.

The question therefore arises as to why the *Lavush* adapted such a complicated system to determine the correct direction. It is possible that he was under the influence of a book of astronomy published a hundred years before in which Levi ben Gershon (1288–1344) described the meridian he made in a synagogue in Spain which he used to determine the position of the planets and the sun.<sup>9</sup> This work became the basis of the *meridiana* that were used in cathedrals in the 14<sup>th</sup> and 15<sup>th</sup> centuries. Levi ben Gershon describes a room in which the distance from the east to west walls is 40 *amot*. Observations are made using a window in the east wall so that the sun’s ray shortly after sunrise can be used to determine the true east-west line. (Levi was well aware that a window was too large for a good camera obscura and made corrections for it in his treatise.) However, although the description would indicate that this was R. Jaffe’s source, the Hebrew is not a direct quotation.

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<sup>6</sup> Zipser, Maier. “Die Rucksicht auf die Ostseite bei Synagogenbauten,” *Ben Chananja*, 1860; 3:9-18.

<sup>7</sup> Eliyahu bar Shmuel, *Yad Eliyahu*, Amsterdam, 1710, Responsa 1, p. 1–4.

<sup>8</sup> The method of calculation of the actual distance to Yerushalayim, e.g., from Baltic Straits of “Zunti” between Riga and Norway, is given on p. 121.

<sup>9</sup> Goldstein, Baruch R. “The Physical Astronomy of Levi ben Gerson,” *Perspectives on Science*, 1997, 5: 1–30; “*The Astronomy of Levi ben Gerson (1288–1344)*.” New York: Springer-Verlag, 1985. Chap. 14.

## The Great Circle

In spherical geometry there are two potentially correct ways to calculate the distance between two points.<sup>10</sup> One can use a circle (the great circle) from the place of origin to the target. Alternatively, one can project the sphere surface onto a flat plane (Mercator map, rhumb line), which was more convenient for navigation by boat or carriage. The differences in length are insignificant for the distance between Europe and Israel. However, the direction and distances are quite different in North America since in distances over 1000 km, the curvature of the earth is apparent. In North America the shortest distance is counterintuitive. It is shorter to travel to the northeast, then through France and down to Israel.

The earliest reference to the problem of the great circle as opposed to the system of the *Lavush* was R. Y. Segal<sup>11</sup> in *Netzach Yisrael* (p. 52a on *Brachot* 30a, 1741). “The *Lavush* erred as did those who followed him” as it did not follow the rules of spherical geometry. “I wish to explain how even though a city can be North of Yerushalayim, a person living there should orientate himself slightly to the North, which is the opposite of the opinion of the *Lavush*.” R. Yisrael Segal seems to be the first to illustrate the problem (Fig. 5). Although he based his calculations and method on the *Yesod HaOlam* (1320) by Isaac Israeli of Toledo and *Sefer Elim* by Joseph Solomon Delmedigo (1629) (“and at the end of the *Elim* you will find all the tables needed as well as in the books I have written”), the actual problem of prayer direction to Yerushalayim is not discussed in the *Sefer Elim*. The *Yesod HaOlam* and *Sefer Elim* based themselves on the works of Euclid and Ptolemy as well as in the

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<sup>10</sup> Levin, Daniel Z. “Which way is Jerusalem? Which way is Mecca? The direction-facing problem in religion and geography” *The Journal of Geography* 2002, 101:27-37.

<sup>11</sup> Segal, Yisrael. *Netzach Yisrael, Kuntras Acharon*, 1741; Frankfort-am-Oder; Freudenthal, Gad. “Hebrew Medieval Science in Zamosc ca. 1730. The Early Years of Rabbi Israel ben Moses Halevy of Zamosc,” in R. Fontaine, A. Schatz, I.E. Zwiep (eds.), *Sepharad in Ashkenaz. Medieval Learning and Eighteenth-Century Enlightened Jewish Discourse* (Amsterdam, Edita 2004), p. 25–68.

case of Joseph Solomon Delmedigo, actually studying under Galileo Galilei.<sup>12</sup>

The problem of the great circle was also addressed in the early part of the 19<sup>th</sup> century by R. Schneier Zalman from Liadi (1745–1812). Basing himself on the *Netzach Yisrael*, R. Zalman states that the further west and north one was to the meridian of Yerushalayim, the direction of prayer could move from slightly southeast to slightly northeast.<sup>13</sup> “It is easy to calculate this direction using spherical geometry (במשולש כדורי).”

## The Compass

Using a compass to determine the direction of Yerushalayim can be problematical because of magnetic declination, which was mentioned by an early 20<sup>th</sup> century Rav, Y.H. Singer.<sup>14</sup> He pointed out that in Russia the magnetic north as shown by the compass is not the true north. (It would give an error of about 30 degrees to the west in Moscow in 1900.)<sup>15</sup> This is of interest, as in the last decade there have appeared advertisements for a kosher compass. This

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<sup>12</sup> Isaac Israeli ben Joseph (*fl.* 1310), *Yesod HaOlam*, Berlin, 1777; Delmedigo, Joseph S. (1591–1655) *Sefer Elim*, Amsterdam 1629.

<sup>13</sup> *Shulchan Aruch* with commentary by Schneier Zalman (*Shulchan Aruch Harav*), *OH* 94, manuscript was completed by 1810. Although the NW orientation was never adopted by North American Jews, there is a recently built synagogue in Lakewood with a deliberately NW orientation. The Lakewood entry to Zmanim.com <<http://www.myzmanim.com/day.aspx?vars=US08701>> contains this chart:

### Davening Direction In Lakewood

#### Following a *Rhumb Line* [?]

Maintains a constant compass direction  
HaRav Yisroel Belsky and others

Bearing 95° ≈ East

#### Following a *Great Circle* [?]

A straight path of shortest distance  
HaRav Yechiel A. Zilber and others

Bearing 54° ≈ North-East

(Key: Bearing 0° = True-North, 90° = East, 180° = South and 270° = West)

<sup>14</sup> Singer, Yehoshua H., *Zichron B'Sefer*, Vilna, 1900 p. 24 on *Berachot* 30.

<sup>15</sup> <<http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp>> .

compass purports to show the direction of prayer to Yerushalayim anywhere in the world. It comes with directions for how to set the compass for each region. In the absence of seeing claimed pending patent, one can assume that it is a simple compass with a bezel that points 90 degrees from compass needle, similar to expensive compasses that correct for declination. However it is difficult to be sure of a device that claims to “appear to defy the laws of nature.”<sup>16</sup> On the site itself, it is recommended by Rav Moshe Halberstam, Rav Moshe Sternbuch, Rav Yosef Lieberman and Rav Yaakov Perlow. Furthermore, in a web communication, “Moshe” (the inventor of the device)<sup>17</sup> states that anyone who claims that the great circle has halachic validity is going against all the great *gedolim* who endorsed his product. This seem disingenuous, as two *acharonim* specifically state that the great circle is the most correct method and explicitly state that the method of the Lavush or rhumb line will give you the wrong direction. In any event, no technical literature is brought in support of the device, so it is not known what sources the inventor used to verify its accuracy.

### Summary

The literature used by *poskim* in the 15<sup>th</sup> to the 19<sup>th</sup> centuries to determine the halachah in astronomy differs from that used by the *poskim* determining zoological or anatomical decisions. In the case of astronomical determinations, the actual observations were done by the Rabbis trained in the discipline, and in the case of Levi ben Gershon, were important contributions to general scientific literature as well. On the other hand, the *poskim* determining the biological data were well educated but not trained in natural sciences.

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<sup>16</sup> <<http://www.koshercompass.com/catalog/>>, accessed Feb 2, 2010.

<sup>17</sup> <<http://observantastronomer.blogspot.com/2005/11/incredible-jerusalem-compass.html>>, accessed Feb 2 2010;  
<<http://parsha.blogspot.com/2005/12/further-info-on-jerusalem-compass.html>>, accessed Feb 3 2010.

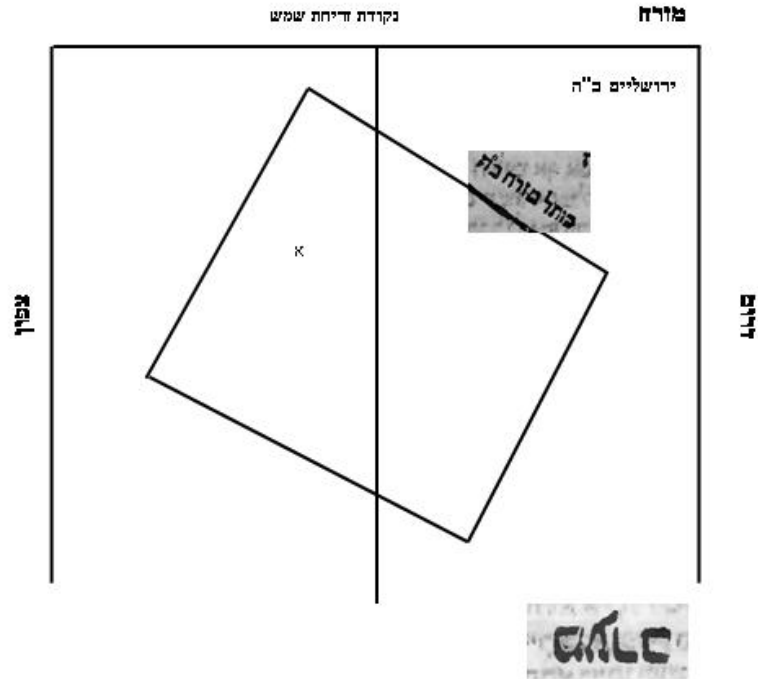
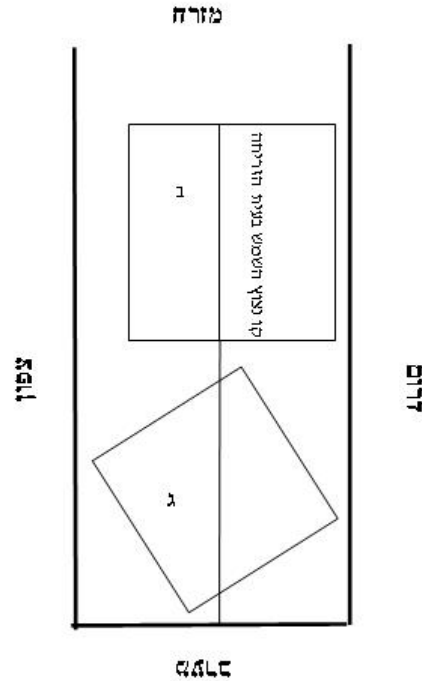


Fig. 1. α “According to the image of a sphere (תמונת צורת כדור), if we position ourselves on the first day of spring or first day of autumn, or close to it within six or seven days, as the sun shines in the morning through the window in the middle of the east wall of the synagogue, and the ray is directed to the western wall; if one moves the spot in the middle of the western wall, an hour or half hour after the sunrise (15 or 30 degrees) to the south (that is 15/360 degrees to the south of the middle of the wall), one reaches the position which is exactly opposite the window of the east, like this:” (All drawings are tracings made by the author.)



*Fig. 1 ב.* “If we position ourselves on the above mentioned days so that the ray of the rising sun through the eastern window directly strikes the western wall like this. Then it would strike the wall exactly due east and this indeed is the way of Magi... and not in the direction of Yerushalayim.” (Magi is used for pagan sun worshippers. It is not clear if the author was aware that the Amogushi [Talmudic form of the word] or Zoroastrians placed a strong emphasis on sun worship.)

*Fig. 1 ג.* “If we position ourselves that the ray of the sunrise on the above-mentioned days and move it towards the north, this would not be in the way of the Magi... but would not be in the direction of Yerushalayim... and this is the picture ג that I have drawn.”



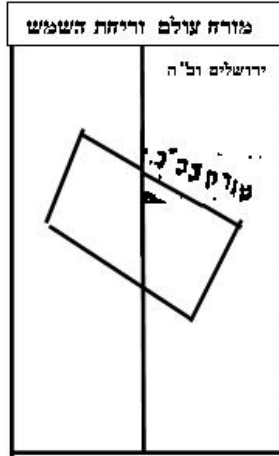


Fig. 2. The rendition of the *Lavush's* drawings as it appears in an early edition of the *Shulchan Aruch* (*Magini Eretz*, Dyhernfurth, 1692).

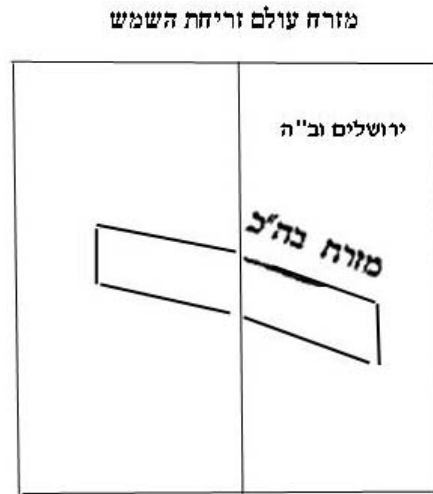


Fig. 3. The rendition of the *Lavush's* drawings as it appears in modern editions of the *Shulchan Aruch* (*El HaMekorot*, Yerushalayim, 1955).

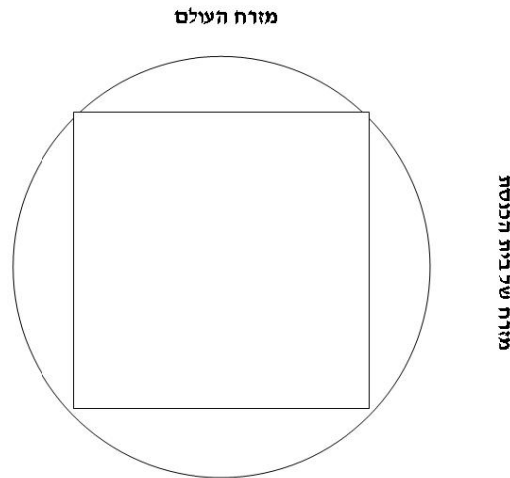


Fig. 4. Orientation of the synagogue that faced due South instead of Southeast discussed by R. Eliyah bar Shmuel. R. Eliyahu thought this could be the result of a misunderstanding of the Lavush.

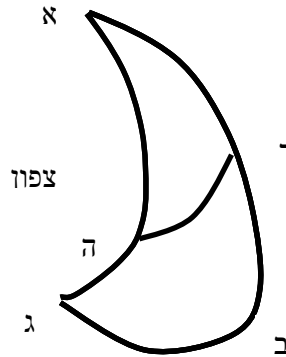


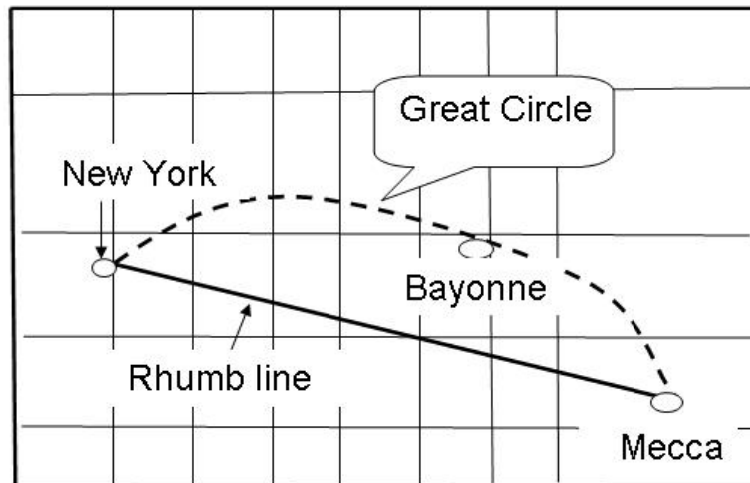
Fig. 5. “The second illustration is about the city of Bayonne, France whose distance in latitude from the equator is 42 degrees and the distance from prime meridian is 17 degrees west (French meridian), and I want to explain how in such a situation one has to face Northeast. This is the illustration: if we take ג as the city in France, and ג-ב is its latitude and ב-ד-א its (Yerushalayim) “quarter circle” from the equator and ג-ה-א is the quarter circle for the city of Bayonne and ה-ד is the arc from “half day” (due east) from Yerushalayim.” *Netzach Yisrael, Kuntras Acharon*, p. 52b.

## Glossary of Terms

**Declination:** The difference between the north geographic pole and the north magnetic pole is called *magnetic declination* or usually just declination. Depending on where you are on the earth, the angle of declination will be different—from some locations, the geographic and magnetic poles are aligned so declination is minimal, but from other spots, the angle between the two poles is fairly large. <<http://www.compassdude.com/compass-declination.shtml>>, accessed Nov. 3, 2010.

**Degrees:** A circle contains 360 degrees. Fifteen degrees would be about 4% of a circle and 30° would be about 8% of a circle.

**Great Circle Route:** By the great circle route, the shortest distance between New York and Mecca is 6,400 miles; the rhumb line, the line of constant direction, is 6,800 miles long.



**Meridian:** A great circle that passes through the earth's poles and any other given point on the earth's surface. In ante meridian (A.M.) and post meridian (P.M), it is the line where the sun is at noon.

**Meridiana:** The Catholic Church provided the means and encouraged improvements for the measurement of the vernal equinox. Paolo del Pozzo Toscanelli, in 1475, designed the first *meridiana* in

the Cathedral of Santa Maria del Fiore, Florence, Italy. He laid down a geographical North/South line (meridiana) and “pierced the lantern” (a hole in the ceiling) which acted as a gnomon. When the spot of sunlight crossed the meridiana it was noon, and when it reached a certain point along the line from north to south, the date of the equinox was determined. <<http://www.analemma.org/presidentspen.html>>; accessed Nov. 3, 2010.

Paris meridian: The present prime meridian (0 degrees) through Greenwich was adapted during the late 19<sup>th</sup> century. Prior to that time there were several prime meridians, including a meridian through Paris. [en.wikipedia.org/wiki/Paris\\_Meridian](http://en.wikipedia.org/wiki/Paris_Meridian)

Rhumb line: A line on the surface of the earth that cuts all meridians at the same angle. It appears as a curved line on the surface of a sphere. Only one such line may be drawn through any two points. Although this is not the shortest distance, the direction is constant.

Spherical geometry: The use of trigonometric equations for determining the distance between two points on a sphere. The most extensive calculations were done by al-Khalili in 14<sup>th</sup> century Damascus, who calculated the distance from Mecca for all areas under Moslem control. <<http://en.wikipedia.org/wiki/Al-Khalili>>. ☞