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Jām-e Gītī-namā
A Late Iranian Qibla-Indicator

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Abstract

Jām-e gītī-namā is a late instrument for determining qibla introduced in a treatise by Muḥammad Riḍā Yazdī (fl. Yazd, ca. 1867) entitled *On Finding Qibla and Some Other Instruments*. The author wrote it to investigate some earlier scientific instruments found at that time including a qibla-indicator. Although he did not describe the instrument in detail, his method of expressing its function leads us to consider it as a Mecca-centered world-map for finding the direction and distance to Mecca. As he found it impossible to determine the direction to Mecca through projecting, he devised *jām-e gītī-namā* to use its numerical results regardless of its spherical representation. This paper examines Muḥammad Riḍā's approach on devising a new instrument for determining qibla inspired by an old one, in order to shed more light on qibla-indicators, more especially, Mecca-centered world-maps.

Keywords: *Jām-e Gītī-namā*, Muḥammad Riḍā Yazdī, Qibla-Indicators, Mecca-Centered World-Maps, Orthographic Projection

Introduction

Much of what we know about the author, Muḥammad Riḍā Yazdī, is from extant treatises either he has compiled or copied.[1]As he was in habit of signing his works usually along with place and date of writing, it is clear that he lived in Yazd and Kerman[2] (two central cities of Iran) and once traveled to Isfahan (see below). In addition to writing on astronomical and mathematical instruments, the similar approach of some manuscripts copied by Muḥammad Riḍā shows his interest and involvement in this subject. In his trip to Isfahan in 1853 (1269 AH), he searched for able scholars to help him solve an astronomical problem, but he claimed he could find no one and eventually he solved it through studying old scientific treatises.[3] There is a unique manuscript compiled by Muḥammad Riḍā preserved in the National Library of Tabriz, Iran,[4] containing seven different treatises of which *on finding qibla and some other instruments* is the fourth. Here we focus on the part of the treatise, introducing an instrument for determining qibla he had found. His aim in writing this treatise is described in his introduction as follows:

> "This is a treatise on introducing and instructions of some instruments made by ancients[5] for time keeping and finding qibla …". (folio 1v)

In this paper first, the way Muḥammad Riḍā tried to describe the old qibla instrument will be outlined, by which his conception of the method becomes clear. This is followed by the method exploited to devise *jām-e gītī-namā* according to tables Muḥammad Riḍā derived from *zīj*es. In the next section, some extant qibla-indicators similar in structure and conception to Muḥammad Riḍā's contribution are

1. While working on this paper, I became aware of a MA thesis in preparation devoted to Muḥammad Riḍā's works on sundials and qibla-indicator by Mrs. Fatemeh Rezaee at Islamic Azad University, Science and Research Branch, Tehran. Considering her historical point of view in comparison to mathematical approach in this paper, definitely this will lead to provide new evidence on the topic,.
2. For example, he wrote *measures and weights* in Yazd in 1841 (1257 AH) according to his statement on folio 3r, facsimile, no. 3101/2 Tehran University Central Library. Also he signed his copy of a treatise on quadrants by al-Māridīnī (d. ca. 1507) in Kerman in 1837 (1253 AH), see Sibṭ-e Māridīnī, folio 6v.
3. Facsimile, Tehran University Central Library no. 3101/5, folio 3v.
4. It is extant in MS no. 3210 of which a photographed copy is preserved in Tehran University Central Library, no. 3101. (No. 679 is also used according to a recent arrangement by the National Library of Tabriz).
5. *i.e.*: those who lived up to the author's date.

presented. Finally, it is shown in concluding remarks, that how studying Muḥammad Riḍā's treatise may provide evidence on Safavid world-maps[1] for finding the direction and distance to Mecca.

1. Mathematical structure of the old instrument

At the beginning of the treatise, Muḥammad Riḍā tries to use the so-called approximate method based on "Indian circle" for finding the direction to Mecca. He puts his city, Yazd, in the center of the horizon circle (Fig. 1) at the meeting point of the Meridian and the east-west line, and then simply joins the locality to Mecca's position. In this method, we just need to know the latitudes (φ) and longitudes (L) of both localities to compute $\Delta\varphi = \varphi - \varphi_M$ and $\Delta L = L - L_M$ in which (φ, L) is Yazd's coordinate and (φ_M , L_M) is Mecca's. It is required to mark off ΔL on the circumference measured westwards from the south point and mark off $\Delta\varphi$ southwards from the west point. As it is shown in Fig. 1, draw two lines parallel to the vertical and horizontal axes through both marks respectively (dashed lines) and then join the center of the circle to their point of intersection (dashed arrow) to find the direction to Mecca with respect to the cardinal directions.[2] Mathematically, this method is equivalent to the formula:

$$q = \tan^{-1}\{\sin\Delta L / \sin\Delta\varphi\},$$

where qibla is measured by q as an angle to the local meridian.

1. Derived from King in his book *World-maps for finding the direction and distance to Mecca* ..., we use the term "Safavid world-maps" to refer to instruments for finding qibla discussed in his book. Also, "Mecca-centered world-maps" is used in general to emphasize their two important characteristics.
2. For more information on this method and its attribution to al-Battānī (*ca.* 910) see King, *World-Maps*, pp. 56-60.

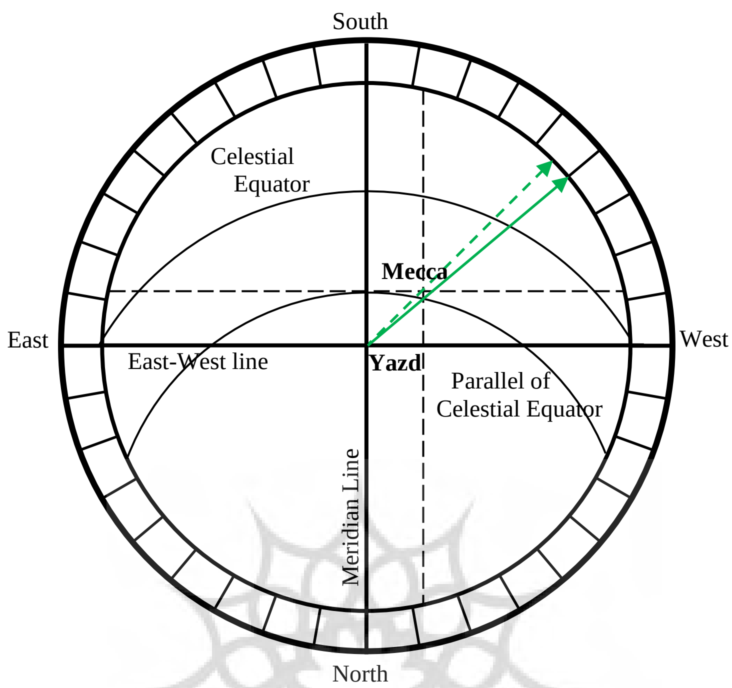

Fig. 1: Two approximate methods for finding qibla by Muḥammad Riḍā. (Illustrated and partially translated from folio 11v. shown in Fig. 3)

Like his predecessors, Muḥammad Riḍā knew the errors underlying this method in comparison to exact procedures. Given the fact that the approximate solutions for finding qibla were all inspired by cartographic consideration (King, *World-Maps*, p. 56), it is not surprising to say that Muḥammad Riḍā tried to modify this method geometrically. To see this, we first consider finding qibla as a problem of spherical astronomy (see *idem*, Ḳibla, pp. 83-84). As shown in Fig. 2, Z_M is the zenith of Mecca above the horizon for which the qibla is desired, namely, NESW. The local zenith is at Z and the celestial pole is at P. Assume that EBAW indicates the celestial equator, $ZA = \varphi$ (= declination of Z). The point C is marked, so that $CA = Z_M B = \varphi_M$ (= declination of Z_M). The distance between the meridian of Z_M and Z is $BA = \Delta L$. Now, finding qibla is converted to a problem of finding the altitude of Z_M, and then the azimuth of Z_M measured from the meridian as $HS = q$.

Now let us turn to Fig. 1 to follow Muḥammad Riḍā's second method. In order to modify the first illustration, he tried to project the spherical circles in Fig. 2 *orthographically* onto the horizon plane. It is necessary to mention that even though in modern terms there is no difference between the celestial sphere and the earth in projecting mathematically, for a medieval astronomer it was not as easy as it is today. As we shall see later, Muḥammad Riḍā made an unsuccessful attempt to project the earth onto a surface through celestial consideration and at last, he found it an incorrect way for finding qibla. For the sake of consistency, we just consider the celestial projection in modern terms and finally refer to Muḥammad Riḍā's point of view.

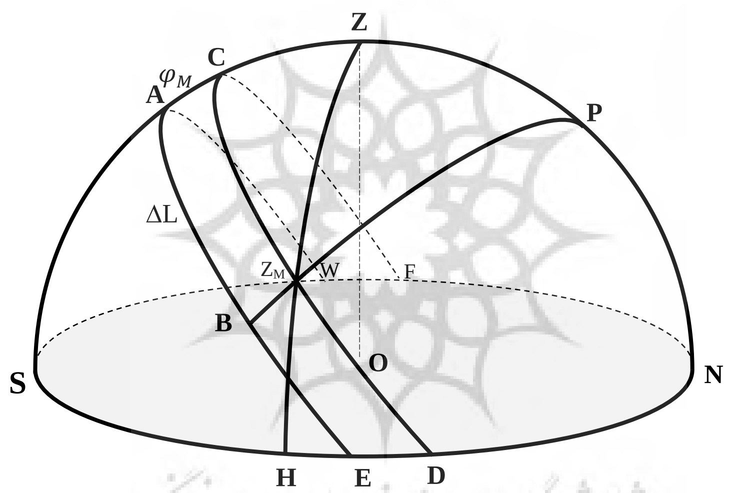

Fig. 2: Finding qibla through spherical astronomy. The determination of the qibla is transferred to the celestial sphere.

Muḥammad Riḍā considered the meridian line in Fig. 1, as the map of the meridian circle (NZS in Fig. 2) and the east-west line as the prime vertical circle (EZW not shown in Fig. 2, a great circle perpendicular to the horizon circle[1]). It takes advantage of the fact that in orthographic projection,[2] all great circles orthogonal to the plane of projection (here the horizon plane) are projected into straight lines passing through the center, and all parallel small circles, likewise, are projected into straight lines. Given this, the small circle parallel to the meridian is projected correctly as a straight line (vertical dashed line in Fig. 1) and Muḥammad Riḍā did not change it in the second method, however, the distance is considered approximately as ΔL. But for oblique circles, the situation is different: the celestial equator and all parallels of latitude must be projected as ellipses that can be approximated as circles (Dekker, p. 114). As it is shown in Fig. 3, Muḥammad Riḍā drew them as circles as it was the same in Safavid world-maps (see King, *World-Maps*, p. 242).

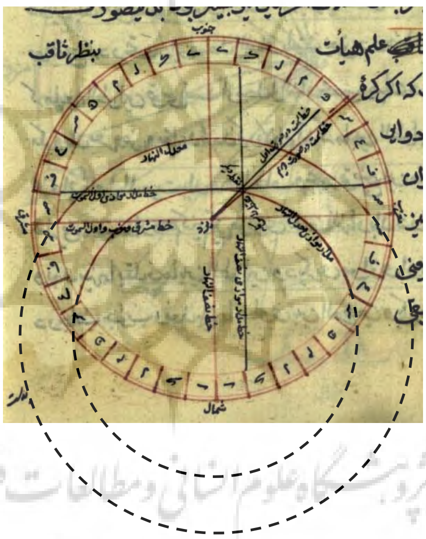

Fig. 3: Dashed curves extended from Muḥammad Riḍā’s drawing show how he illustrated celestial equator and parallel of Mecca as circles by means of a compass. (Extracted from folio 11v, courtesy of the National Library of Tabriz; see Fig. 1 for translation)

1. Note that unlike Yazd in Fig. 1, the city is considered to the west of Mecca in Fig. 2 to have a better understanding. This visual change does not interfere with the process we follow.
2. In orthographic projection, projection lines are orthogonal from infinity onto the plane. It is noteworthy that the projection described here is *oblique orthographic projection*, whose center is somewhere between equator and a pole. On orthographic projection as the best known azimuthal projection, see Snyder, pp. 145-146.

Following Muḥammad Riḍā's operation, it is obvious that he was trying to find qibla graphically. Moreover, using orthographic projection, it is more likely that the instrument he had found was similar to the world-maps for finding qibla. But these are not the only reasons for this argument. In the rest of the paper, more promising evidence will be presented.

A related point to consider is that Muslim scholars were familiar with orthographic projection inherited from their predecessors. They used it for centuries in *analemma construction,* in particular for finding qibla.[1] In 2000, Elly Dekker showed the method underlying Safavid world-maps for finding qibla is *retro-azimuthal orthographic projection*. Considering numerical methods, she believed that this might have had a European origin and was impossible for Muslims at that time to carry out such an operation. Her claim was soon challenged by providing evidence on Muslims' geometrical capabilities, drawing attention to analemma construction and conic sections (Hogendijk, *Het mysterie…*; King, *In Synchrony*, pp. 831-846). We shall return to this subject in the last section. Regardless of the method used for projecting, the only thing that matters here is the fact that through orthogonal mapping onto the horizon plane of Mecca, the projections of the celestial equator and all parallels of latitude are ellipses.

Now let us move to Muḥammad Riḍā's method. Completing the orthographic projection, he illustrated the projections of the celestial equator and the parallel of Mecca as it is shown in Fig. 1. Then, by joining the center of the circle to the meeting point of the vertical dashed line (in its second notion) and parallel of Mecca, a new qibla direction was acquired (measured by the angle between the solid arrow and the local meridian). Referring to the difference between the results in his two methods, he concluded that even though the second direction is closer to the true qibla, but:

"It is evident to every astronomer with a deep insight that if we project the earth with all of its imaginary circles, the true qibla will not be derived too." (folio 11v)

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1. There are several studies on analemmas in Islamic history. On analemmas for finding qibla, for example, see Berggren.

Through this statement, Muḥammad Riḍā pointed out his aim of projecting *the earth* onto a surface cartographically, although he confused the circles of the earth with the celestial circles. As he did not believe in the method, it seems more likely that he was trying to find the underlying methodology of a world-map for finding qibla he might have found. A related question discussed in the following section is how Muḥammad Riḍā took advantage of this idea to make his own qibla-indicator called *jām-e gītī-namā*.

2. Muḥammad Riḍā on devising a new qibla-indicator

Unlike Mecca-centered world-maps, *jām-e gītī-namā* served just for *indicating* and not for *finding* the qibla directions. Thus, as it is the case with modern instruments, the name "qibla-indicator" instead of "qibla-finder" seems more acceptable to this kind of instruments. Despite a failed attempt at the beginning, Muḥammad Riḍā presented no methods for *finding* qibla and simply relinquished it to his predecessors' contributions:

> "The mentioned angle (*inḥirāf*) can be determined by two methods; one through (using) manufactured instruments like globes, astrolabes, sine quadrants, proportional compasses, *etc*. ... and one through computing based on *zīj*es and other similar texts." (folio 12r)

He gives a table of 70 localities with their longitudes and latitudes,[1] and also their qiblas in degrees and minutes besides their declinations according to the cardinal directions and their distances to Mecca,[2] the latter in degrees and minutes and also in *farsakhs*.[3] As it is shown in Fig. 4, he illustrates a Mecca-centered circle on a piece of paper,[4] being

1. In the treatise investigated in this paper, *zīj*es used by Muḥammad Riḍā are nowhere stated; but in his *Anthology* (facsimile, Tehran University Central Library no. 3101/6) there are some hints to *Muḥammad-Shāhī Zīj* (*e.g*: folio 10r), and (*Sultānī*) *Zīj* of Ulugh Beig (*e.g:* folio 11r). Certainly future research is required to reveal the *zīj*es behind Muḥammad Riḍā's tables.
2. It is of interest to know that Muḥammad Riḍā gives also a set of tables for other holy cities, in particular important Shiʿite centers: Medina, Kufa (same coordinates as Najaf and Kerbela) and Meshed. He reports that he made *jām-e gītī-namā*s with different plates according to these tables. It was a common tradition amongst Shiʿite instrument-makers to present the directions of holy shrines on the instruments. For more information see King, *World-Maps*, p. 120.
3. A *farsakh* is three *mīls*, roughly equivalent to six kilometers (see *ibid*, p. 87 (footnote 105); *Dehkhoda Dictionary*, under "فرسخ").
4. He remarks that the bigger the circle, the better the result. According to his statement, he draws the circle in one span (*shibr*) and a half diameter that is about 34 centimeters.

divided into four graduated quadrants by drawing meridian and east-west lines perpendicular at the center denoting the cardinal directions. His idea to use a Mecca-centered scheme supports our conjecture about the old qibla-indicator; although, he started the work with a city-centered plan (Fig. 1). To prepare the diametrical rule (*ʾiḍāda*), he lays the rule on the meridian line and divides it using straight lines joining each degree in the lower-half of the circle (Fig. 4). This results in a non-uniform scale that Muslim astronomers were familiar with since the 9th century (King, *World-Maps*, p. 237). Muḥammad Riḍā’s argument on using such a method is remarkable:

> “If we project the parts of a great circle passing through the zenith, the half of its diameter would be divided into these parts.” (folio 14r)

Again, he applies orthographic projection, in this case, for a celestial circle that he knows well it can serve as a terrestrial circle. Muḥammad Riḍā, like most of his predecessors, takes one degree on a terrestrial great circle as 22 2/9 *farsakhs* (see below) based on Ptolemy’s measurement.[1] Having a better understanding, we simply need to suppose the east (or west) point in Fig. 4 as the zenith of Mecca and try to project the crossing great circle onto the diameter plane orthographically.

Now to find the position of each locality, he needs just two parameters: the qibla direction (q), and (the sine of) the distance to Mecca (d)[2] in degrees or *farsakhs* that are all given in his tables. As he gave an example for Yazd in Fig. 4, firstly, one has to put the centralized diametrical rule on the given degree (q) along the circumferential scales and then mark the relevant distance (sin d) on the diametrical rule in terms of its scales to find a city’s position on the plate.

1. For more information see for example King, *World-Maps*, pp. 237-238.

2 To supply a vivid imagination for a modern reader, we note that in Fig. 2, the arc ZZ_M represents the distance (d) between two localities with zeniths at Z and Z_M.

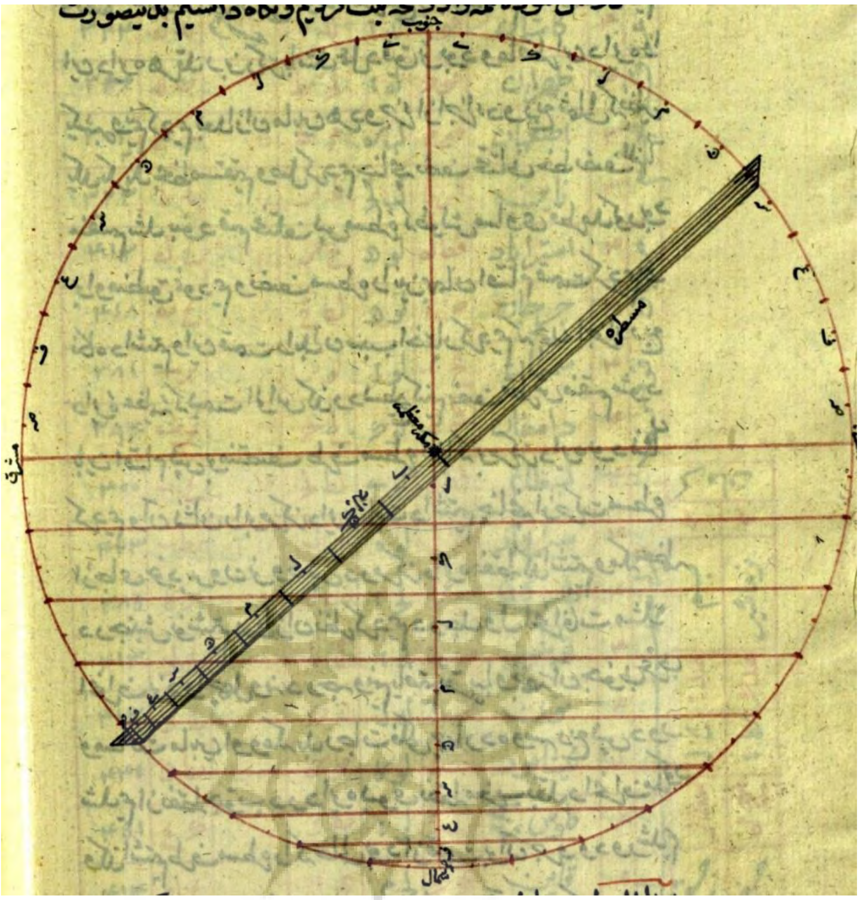

Fig. 4: Muḥammad Riḍā's Mecca-centered plate. Here he shows his method of determining the distance-scale on the rule and finding the position of Yazd on the plate as an example. (Extracted from folio 14v, courtesy of the National Library of Tabriz)

According to King, this operation is based on the results of the so-called "method of the *zīj*es" (*ibid*, pp. 241).[1] It involves three auxiliary quantities, that is, "modified longitude difference": $\Delta L'$, "modified latitude (of Mecca): φ_M', and "modified latitude difference": $\Delta\varphi' = \varphi - \varphi'_M$, which yields the direction and (the sine of) the distance to Mecca through trigonometric expressions:

1. For more information about the method of the *zīj*es, see *ibid*, pp. 61-64.

$$\sin \Delta L' = \sin \Delta L . \cos \varphi_M$$

$$\sin \varphi'_M = \frac{\sin \varphi_M}{\cos \Delta L'}$$

$$\mathrm{cosd} = \cos \Delta L' . \cos \Delta \varphi'$$

$$\sin q = \frac{\sin \Delta L'}{\sin d}$$

As a result, if we tabulate $q(\Delta L, \varphi)$ and $d(\Delta L, \varphi)$ like what Muḥammad Riḍā did,[1] we will be capable of establishing a Mecca-centered qibla-indicator utilizing the procedure in Fig. 5 (based on the last equation above):

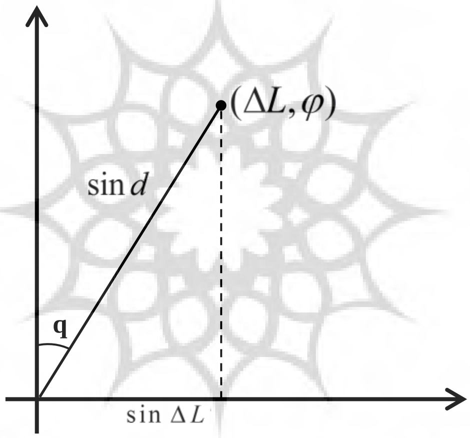

Fig. 5: How Muḥammad Riḍā took advantage of the method of the *zīj*es to find different localities on a Mecca-centered plate (King, *World-Maps*, pp. 241-242)

Someone, familiar with Mecca-centered world-maps, may think that the construction underlying Muḥammad Riḍā's circular scheme represents the final design of his new instrument. But surprisingly, it does not. The remaining procedure makes it all the more obvious that he is by no means convinced of a Mecca-centered world-map. It seems

1. Note that by shifting φ and φ_M , equations result in a Mecca-centred scheme.

that to him, the idea of putting Mecca at the center was just a theoretical definition of the problem, not an appropriate graphical representation.

Muḥammad Riḍā's illustration of his new instrument is shown in Fig. 6. He superimposes his circular scheme over a rectangular wooden plate in a position that the meridian line is parallel to the longer side of the plate. So he can copy the localities using a needle. Interestingly enough, there is no attempt to put Mecca or any other city at the center of the plate. Attaching a compass on the vertical axis of the wooden plate, that is the meridian, the cardinal directions can be determined. As the pivoted diametrical rule is useless here, the plate is fitted with a non-uniform scale illustrated on the bottom. Thus, according to the instruction prepared to be written on the back of the plate (the left side of Fig. 6), the distance between every two localities, including a locality's distance to Mecca, can be acquired by measuring the imaginary straight line connecting two desired points of cities using compass and then multiplying the corresponding degrees on the diametrical rule by 22 2/9 to have the distance in *farsakhs*.[1] Also, a gnomon erected in the hollow in the middle of the meridian line can be used to determine the midday. A detailed instruction is considered to be written on the back, so users would not need any more information.

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1. He points out that it gives "the distance along a straight line" between two localities (folio 15r) that is in modern term equivalent to "the sine of the distance".

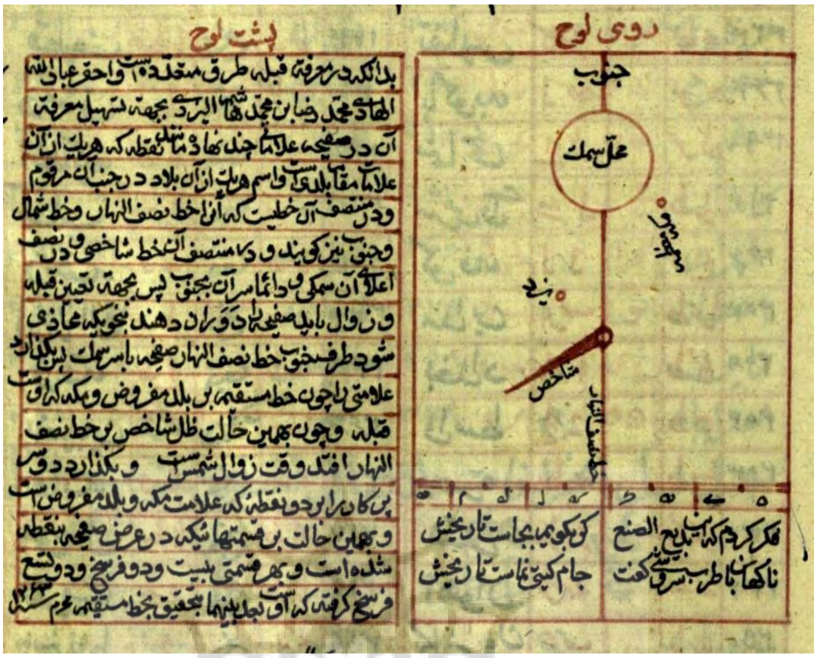

Fig. 6: Muḥammad Riḍā's illustration of his own instrument. On the right is the face side of *jām-e gītī-namā* and on the left is the instruction and the date of fabrication (at the lower end) to be inscribed on the back. Also the name and the date of invention composed in verse are displayed on the lower right. (Extracted from folio 15r, courtesy of the National Library of Tabriz)

Muḥammad Riḍā names his new instrument *jām-e gītī-namā* (*i.e*: the mirror for observing the universe).[1] According to the author, a poem in four lines was suggested by one of his friends to present the name and the date of the instrument:

فکر کردم که این بدیع الصنع   گر بگویم بجاست تاریخش

ناگهان با طرب سروشی گفت   جام گیتی نـماست تاریخش

"It occurred to me that it is fitting to mention the date of fabrication of this newfound instrument; suddenly an angel (*surūsh*) said with alacrity: the date is *jām-e gītī-namā*".

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1. *Jām-e gītī-namā*, also known as *jām-e jam* and *jām-e jahān-namā*, is a well-known cup of divination or mirror in Persian Mythology, that the whole world was said to be reflected in it. Accordingly, this name was used for some geographical maps and books and also for instruments such as astrolabes and globes. For more information on historical background see *Dehkhoda Dictionary*, under "جام جهان نما".

Adding the numerical equivalents in the *abjad* system of each of the letters of underlined words (based on a technique behind the Persian composition), the date of invention is derived from the chronogram as 1246 AH (1830) that is written (perhaps mistakenly) 1245 AH in the treatise. It seems unusual that about seventeen years later, in 1846 (1263 AH), the instrument was made according to Muḥammad Riḍā's description (Fig. 6). Perhaps, it was due to the date of preparing the treatise.

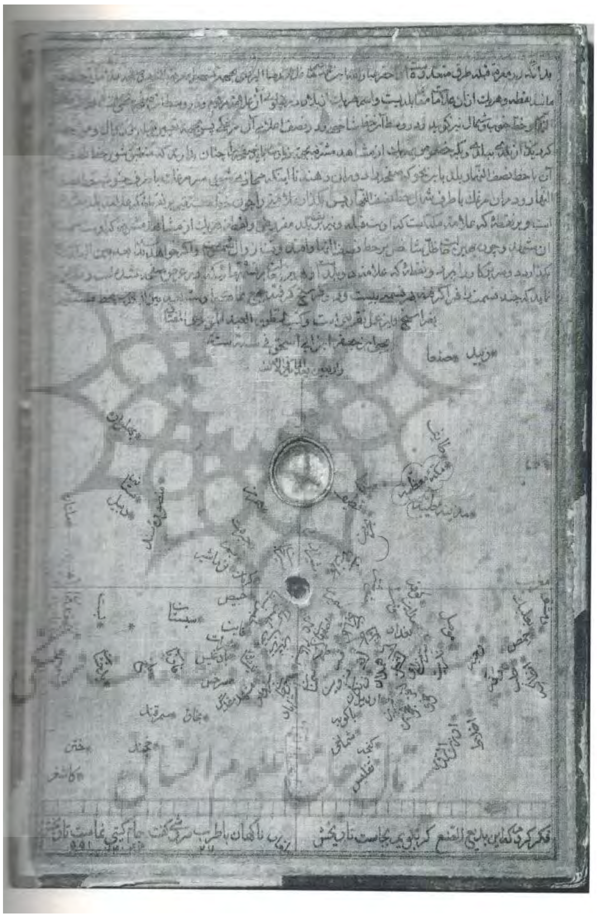

Fig. 7: A *jām-e gītī-numā* preserved in Staatliches Museum für Völkerkunde, Munich. Around 90 small dots with names of cities are marked on its wooden plate and the verse as chronogram can be seen along the lower edge. (Photo extracted from Newid, p. 45, courtesy of the author)

Surprisingly, an instrument of the same kind is extant in Staatliches Museum für Völkerkunde in Munich (shown in Fig. 7) that I first became aware of it from a photo displayed on King (*World-Maps*, p. 98). Now that in the light of Muḥammad Riḍā's treatise the mathematical method underlying this instrument is unveiled, we can confidently say that *jām-e gītī-namā* is a bit more than a "simple Iranian qibla-indicator (*ibid*, p. 95)". As will be discussed in the next section, there are some other late qibla-indicators that may have been inspired by the same idea.

3. On Some late Iranian qibla-indicators

As mentioned above, Fig. 7 shows a photo of extant *jām-e gītī-namā* which is similar in properties to the instrument Muḥammad Riḍā describes in his treatise, although close inspection reveals some differences in detail. The accompanying inscription attributes the design to Ibn Muḥammad Hāshim (the son of Muḥammad Hāshim), Ghulām Riḍā al-Yazdī.[1] His father's name is the same as Muḥammad Riḍā's and he also makes claim to have invented the instrument. Unlike Muḥammad Riḍā, I could not find any treatise compiled or copied by his (potential) brother. In addition, the careless distance-scale and Ghulām Riḍā's claim to present an "approximate" method are totally different from Muḥammad Riḍā's contribution in his treatise. Yahyā Ibn Jaʿfar Ibn Abī Īshāq, the copyist (or just the scribe of the inscription) of the instrument gives 1830 (1246 A. H.) as the manufacturing date which is exactly the date of the fabrication of *jām-e gītī-namā* by Muḥammad Riḍā (mentioned earlier). Although these questionable historical findings merit future studies, they do not detract from mathematical achievement in Muḥammad Riḍā's treatise underlined in this paper.

1. It was a common tradition for authors or makers to sign themselves with their father's name first.

Fig. 8: Oxford Mecca-centered qibla-indicator: The verse inscribed on the rim is visible in this photo. Unfortunately, this late exciting instrument is unsigned and undated. (Museum of the History of Science, Oxford)

Looking for other similar extant pieces, I came across a late Iranian qibla-indicator with a map centered on Mecca preserved in Museum of the History of Science in Oxford (Fig. 8). This circular wooden plate of some 7.5 cm in diameter is investigated in detail by King (*World-Maps*, pp. 96-97, 359 and 544) as "a simplified version of the Safavid world-maps". Considerable similarities such as containing a compass, being fitted with markings for a horizontal sundial and, above all, having Mecca at the center of the plate, impress everyone interested in Safavid world-maps. Moreover, since it is also innocent of any grid (different localities are simply marked by colored points with names of the cities), I found it capable of being influenced by the method behind *jām-e gītī-namā*. Surprisingly, a closer look at the instrument's photos supports the idea. A part of the verse discernible on the rim of this qibla-indicator (Fig. 8) denotes that it has more in common with Safavid world-maps than what was expected. It is specifically the first four lines out of six of the poem engraved on the Safavid world-maps (reasonably the last two lines related to the plate of hours are ignored). It implies that the maker of Oxford qibla-indicator was well aware of Safavid world-maps and, like Muḥammad Riḍā, tried to rebuild the instrument in a noncartographic design. But in this case, something does not fit; the third and fourth lines engraved on Safavid world-maps read (*ibid*, p. 204):

اگر ستاره را بر عرض و طول شهر بُگذاری   شَوی از قبله و بُعد بلد از قبله مستحضر

> "When you put the diametrical rule at (the intersection point of corresponding) latitude and longitude of the desired city, you will acquire the qibla and the distance of the city from Mecca".

The point is that from the viewpoint of Muḥammad Riḍā and his colleagues, there is nothing representing "latitude and longitude" of localities on their qibla-indicators. As noted earlier, Muḥammad Riḍā denounced any projection of the earth's surface for finding qibla, and if the maker of Oxford qibla-indicator was influenced by this method, how could he simply copy the conflicting inscription? Unfortunately, the controversial part of the instrument bearing the related line of the poem is not visible in various photos displayed on the official website for the Museum of the History of Science in Oxford.[1] Therefore, my attention was drawn to another qibla-indicator of the same kind auctioned at Sotheby's of London in 2010. Since the photo is no longer available on the website, I am not allowed to publish it here; however, a favorite image along with a brief description is accessible in *Sotheby's Catalogue* (p. 88: lot. 122).

It was an exciting moment for me to find the desired part of the verse on Sotheby's photo of the qibla-indicator. By a closer look at the image[2] I realized that the intelligent instrument-maker was well aware of this fact that the meaning of the poem goes against his principle and thus decided to revise it as follows:

اگر ستاره را بر نقطهٔ هر شهر بگذاری

"When you put the diametrical rule at the point of each city, …".

The underlined words in the original Persian verse, meaning "latitude and longitude [of a city]" are carefully replaced by the latter underlined terms for "the point of each [city]" to change the geographical view into a merely mathematical scheme in keeping with the rhythm of the main poem. According to the description in *Sotheby's Catalogue*, this qibla-

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1. http://www.mhs.ox.ac.uk (inventory number: 43645).
2. The text on the image is barely legible at first glance.

indicator dates back to 1872 (1289 AH) and the maker (or copyist) is also named: the son of Abul Qāsim al-Kirmānī, Muhammad Ḥusayn [*al-Shahīr*…[1]].

More important is the name *ṣafhi-yi jahān-namā* inscribed at the back side of Oxford qibla-indicator. Meaning “a plate for observing the universe”, this is similar in notion and in phrasing to the name of *jām-e gītī-namā* (see footnote 20). All of these findings support the idea that gridless Mecca-centered qibla-indicators can be developed versions of *jām-e gītī-namā*, taking inspiration from the Safavid world-maps.

A related point to consider is that regarding the limited area, this instrument was not applicable for more than about 30 localities. Thus, an extensive list of qibla values for different cities in degrees is inscribed on the back to find the direction to Mecca simply by putting the pivoted rule on the corresponding degree around the rim, with respect to the cardinal directions being already derived by the compass. The makers might take it one step further to result in smaller qibla-indicators using the latter method, having no need for a plate of localities and a diametrical rule (Fig. 9). In support of this claim, it can be remarked that qibla-indicators of this kind were in use in 19th Iran, called *āyʾīni-yi gītī-namā*, again a name similar to *jām-e gītī-namā* (just using a synonym that is *āyʾīni*, instead of *jām*, meaning “mirror”).

1. *Al-Shahīr* is confused with a part of the maker’s name while this Arabic word, meaning “known as”, is used to introduce a person’s title or epithet.

Fig. 9: A brass qibla-indicator of the kind of "*āyʾīni-yi gītī-numā*". The distinctive verse engraved on the rim is barely legible. (Museum of the History of Science, Oxford)

The characteristic and properties of this kind of qibla-indicator are again featured through a verse in four lines engraved on the rim as follows:

از این آیینهٔ گیتی نما گر قبله را جویی   به عقرب نقطهٔ چرخ جنوبی را بکن میزان
ببین بُعد بلد را از جنوب و از شمال آنگه   به هر سو منتهی گردید سمت قبله باشد آن

> "If you want to determine the qibla with *āyʾīni-yi gītī-namā*, you have to put the compass in a way that needle is parallel to the [north-] south line; Put the rule on desired qibla value acquired from those [engraved] on the instrument, thus it will show the direction [to Mecca]".[1]

It seems that this kind of qibla-indicators was in wide use. Suffice it to say that thanks to good-quality photos displayed on the website, I have found four qibla-indicators with the same verse engraved on their rims in Museum of the History of Science in Oxford.[2] This late qibla-

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1. I first became aware of "*āyʾīni-yi gītī-namā*" according to a report by Hasan Zade Amoli (vol. 2, p. 665) on a special qibla-indicator he had at his disposal. The related verse written in this paper is based on his report, although I have come across some small differences in other instruments of this kind. The qibla-indicator described by Hasan Zade Amoli is much like the one with 50254 inventory number in Museum of the History of Science in Oxford.
2. Their inventory numbers are: 53791 (Fig. 9), 50596, 34566, and 50254. Also a qibla-indicator with 1890,0315.4 museum number in the British Museum, and another one auctioned at

indicator also takes advantage of the idea of putting Mecca at the center of a plate to find qibla, even though there is not any hint engraved on the instrument. Apart from that, most of the *āy'īni-yi gītī-namā*s are accompanied by a gnomon or markings for a horizontal sundial as it is the case with *jām-e gītī-namā*. Considering similarities in structure, alongside the inspiring verse and name, a relationship between *jām-e gītī-namā* and *āy'īni-yi gītī-namā* seems plausible.

Concluding remarks

As it was noted earlier, Muslim astronomers turned the problem of finding qibla from a geographical view to an issue in spherical. As a result of considering the zenith of Mecca instead of its terrestrial coordinates in the problem, observational methods came into consideration; for the zenith of Mecca was treated as a celestial object. To a Muslim scholar, geometrical methods derived from the spherical representation of the universe operated in parallel with observational astronomy. In this case, computational methods, despite their spherical (astronomical) origins, bore a different approach.[1]

In this regard, the way Muḥammad Riḍā approached the mathematical method underlying Safavid world-maps, reflects substantial differences between these two approaches. In his point of view, the true numerical solution did not necessarily result in true geometrical representation. Moreover, he considered the Safavid world-map as a projection of the earth's surface and tried to reveal the underlying method using an unsuccessful projection of the celestial hemisphere over the horizon plane before finding it impossible (section 1). Now the question is that what could be the imagination of Safavid instrument-maker to create such an elegant world-map that Muḥammad Riḍā could not grasp? As far as we know, no explanation is found in

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Christie's of London (according to a photo published in King, *World-Maps*, p. 124) are of the same kind. Although these qibla-indicators are different in detail, their general construction and function are the same. Since I have recognized them based on photos, unexpected differences are also possible.

1. For example, I refer to a scientific classification of methods for finding qibla by Ghiyāth al-Dīn Manṣūr Dashtakī (1460-1543) in his *Risāla-yi Qibla*. Significantly, he introduced the method of determining qibla by observing astronomical horizon phenomena such as rising amplitude as a geometrical method, while he classified the procedure of using analemma construction for finding qibla in the same category (see edited Arabic text in Musavi, pp. 148 and 154). On the other hand, methods based on calculation like trigonometric functions in the method of the zījes were treated simply as numerical solutions (ibid, pp. 156-157).

extant manuscripts, even though many of them remain unstudied. Nevertheless, regarding the significance of instructions composed in verse to be inscribed on qibla-indicators (as discussed in this paper), the poem engraved on Safavid world-maps may also have more to tell us. The first line reads:

در این صحرا که در معنی زمین و آسمانستی

"In this plain, that means (represents) the earth and the sky…".[1]

Then, the plate of the instrument is introduced as a plane reflecting the earth (the land) and the sky together. The quoted verse supports the idea of astronomical representation behind the instrument rather than a geographical view. It implies that even though Safavid world-maps represent a great achievement in the history of cartography, they have to be treated in the context of Islamic science they flourished in. Accordingly, Islamic astronomical and generally, geometrical methods for finding qibla are of significance in research on Safavid world-maps (see Hogendijk, *Three Instruments*). Finally, I would like to add two new pieces of evidence on using geometrical methods creatively by Safavid scholars that may support the conjecture:

Muḥammad Bāqir Yazdī (alive in 1637=1047 AH) used analemma construction as "an extremely elegant way of determining qibla" in devising his instrument called *Matlaʿ al-Anwār*. Although he did not mention anything about a world-map, taking advantage of a centralized diametrical rule in this instrument seems remarkable.[2] A much more interesting case is what Muẓaffar al-Gunābādī (d. ca. 1630=1040 AH) reported in his treatise *Tuḥfe-yi Ḥātamīyya*. After explaining the standard geometrical method based on Indian circle (see Fig. 1), he noted that "as it is just an approximate scheme (projection?) for finding qibla, Mīrzā Qāsim Junābidhī (Gunābādī) compiled a table of entries for accurate scale of the vertical line(s?) (folio 10v)". The described line(s?) could be served as parallel meridian lines in Safavid world-maps.

1. Literary translation by King gives an implicit concept of the poem, somewhat different from a word-by-word translation: "In this stone is significance on land and on sea (*World-Maps*, p. 205)"; however, this approach may explain why the maker of Oxford qibla-indicator (see section 3) did not change this line of the verse like as he did for the third.

2. I have had a short talk on this instrument in 35th Scientific Instrument Symposium (Istanbul, 26-30 September 2016) and an article is in preparation.

Unfortunately, he gives no more information other than nothing had been done to prepare a similar table for (projected) horizontal small circles. And again unfortunately, I have not already found any scientific treatise attributed to Mīrzā Qāsim that is most probably Muẓaffar’s father.[1] Considering limited historical evidence, we are not able to judge whether he was capable of providing such a table or not;[2] but in any case, Muẓaffar’s phrase supports the idea that conception behind the Safavid world-map was astronomical rather than geographical. Definitely, all of this material merits detailed study.

1. He was a student of Dashtakī (see Musavi, pp. 102-103).
2. On Muẓaffar al-Gunābādī and his family connection see *ibid*, p. 178. Here, King gives an example that casts doubt on considering Muẓaffar (not his father) a competent astronomer.

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