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FROM AL-KURA TO BHAGOLA ON THE DISSEMINATION OF THE CELESTIAL GLOBE IN INDIA

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I. Introduction

In the context of the transmission of astronomical instruments from the Islamic world to India between the 14th and 18th centuries, I wish to examine in this paper the dissemination of the celestial globe and its reception by Hindu astronomers.

Described quite elaborately by Ptolemy in his *Almagest* (VIII 3), the celestial globe is a convenient instrument for mapping the star positions and storing them.[1] It was adopted both in medieval Europe and in the Islamic world. In Europe, it came to be treated as the emblem par excellence of the astronomer just as the astrolabe was considered his chief symbol in the Islamic world. European portraits of the astronomer, like those of Copernicus or Kepler, usually show him plotting the star positions on the globe by means of a pair of compasses. During the Renaissance, automatically rotating globes with clockwork mechanism were made in large numbers and these represented the highpoint of technology as well as the goldsmith's craft.

In the Islamic world several treatises were written on this globe and innovations were made in its construction. In Arabic, it is called *al-Kura* "the sphere", *al-Bayḍa* "the egg" or *D̲h̲āt al-Kursī* "the instrument resting in a horizontal frame".[2] In the early 12th century, al-K̲h̲āzinī designed a globe that rotated automatically by means of a falling weight in a leaking reservoir of sand.[3]

The earliest extant globe in the Islamic world was manufactured by Ibraham ibn Saᶜīd in Moorish Spain in 473 AH/1080 AD.[4] Muᶜayyad al-Dīn al-ᶜUrḍī, the celebrated instrument-maker of the Marāg̲h̲a observatory, does not include it in his treatise on instruments,[5] but a specimen crafted by his son Muḥammad ibn Muᶜayyad al-ᶜUrḍī in 1278 AD is preserved in Dresden.[6] Made by joining two brass hemispheres, it is engraved and inlaid with gold and silver. It can be made to rotate around the equatorial axis as well as the eclipitc axis. Apparently a similar model was taken from Marāg̲h̲a to the court of the Mongol emperor Kublai K̲h̲ān by a certain Jamāl al-Dīn in 1267 AD together with many other astronomical instruments.[7] Al-Saman describes what is supposed to be a second extant globe by Muḥammad ibn Muᶜayyad al-ᶜUrḍī.

In India, automatic globes were envisaged as teaching instruments. Towards the end of the fifth century AD, Āryabhaṭa speaks of an automatically rotating (*svayamvaha*) globe (*gola*), the motive power for which is provided by a sinking float in an outflow type of water clock.[8] However, this globe was not intended to map star positions but only to demonstrate apparent motion of the great circles. The real celestial globe with star positions marked on it is a late-comer to India. It was introduced in this country by the Mughal emperor Humāyūn in the middle of the 16th century.

2. *Humāyūn's Interest in Astronomy*

Humāyūn (reign 1530-1556) was greatly interested in astronomical instruments.[9] Abul Faḍl, minister and chief chronicler of his son Akbar, often speaks in glowing terms of Humāyūn's interest in astronomy. Thus he says at one place that "His Majesty, who in astrolabic investigations and studies in astronomical tables and observations was at the head of the enthroned ones of acute knowledge and who was a second Alexander..."[10] Elsewhere, employing an astronomical metaphor, he calls Humāyūn "the alidad of the astrolabe of theory and practice".[11]

When Humāyūn lost the throne of India and wandered through Persia and Iraq, his constant companions were astronomers. The chronicles never tire of declaring that he was quite adept in the use of the astrolable. His sister reports that when he became impatient of waiting for Hamida Bano's consent to marry him, he took the "astroloabe into his blessed hands" and himself fixed the auspicious moment for their wedding.[12]

Planetary symbolism pervaded his daily routine, the decor of his court and even his amusements. He is said to have invented a kind of astrological monopoly game where, instead of squares, there were circles representing the nine cosmic spheres. These circles were painted in the respective colours attributed to the spheres. The courtiers acted as the pawns and moved from one circle to the other according to the throw of dice.

Astronomy, as is well known, was also the cause of Humāyūn's untimely death. Waiting one evening in his library for the appearance of Venus, he heard the call for prayers and rushed down the stairs. In his haste, he slipped and fell, and succumbed to his injuries.

His interest in the celestial globe is revealed in an anecdote narrated by Abul Faḍl:[13] "When Humāyūn reached Tabrīz during his journey in Persia, he ordered his slave Pik Muḥammad Akhta Begi to search for a celestial globe—*kura*—in that city, as he was very keen about astrolabes, globes and other observatory instruments. In

Persian *kura* means a colt, so his simple slave obeyed the orders by bringing a number of colts to the royal presence. The king laughed when he saw the multitude of colts and mares before him, and bought them all the same as a good omen."

3. *Allāhdād the Royal Astrolabist*

Under the active patronage of Humāyūn, astrolabes and celestial globes began to be manufactured in India. Astrolabes must have been made even before this time, though no actual specimens are extant today. The existence of several Sanskrit manuals on the construction and use of the astrolabe[14] testifies to the fact that this versatile instrument, called therefore in Sanskrit *yantrarāja* "king of astronomical instruments", must have been used both by Muslims and Hindus/Jains at least from the reign of Fīroz Shāh Tughlaq in the second half of the fourteenth century.

Fīroz promoted, probably for the first time, manufacture of astrolabes in India. He also caused manuals to be written on the construction and use of the astrolabe both in Persian and Sanskrit.[15] The first Sanskrit manual on the astrolabe, composed at his instance in 1370 AD by the Jaina monk Mahendra Sūri is extant.[16] The Persian manual is no more extant but its summary survives in the anonymous chronicle *Sīrat-i Fīroz Shāhī*, which was also composed in 1370. There is, however, no mention of the celestial globe in India before Humāyūn's time.

The *Ā'īn-i-Akbarī* reports that the astrolabes and globes produced by Maulānā Maqṣūd of Hirāt, one of the servants of Humāyūn, were much admired by Cognoscenti[17], but none of them seems to have survived.

Humāyūn's chief astrolabist, however, was Master Allāhdād of Lahore, who signed his creations as Ustād Shaykh Allāhdād Asturlābī Humāyūnī Lāhorī. He and his descendants of the next four generations were the chief producers of astrolabes and celestial globes in India. Some 80 astrolabes and more than 20 celestial globes bear the signatures of the various members of this family. Besides these, a number of unsigned pieces are also attributed to this family on stylistic grounds. In 1935, Sayyid Sulaiman Nadvi[18] made for the first time a survey of the instruments produced by the members of this family. More recently in 1985, Emilie Savage-Smith, in her exemplary study of the Islamic globes,[19] discussed in great detail those manufactured by Allāhdād family.

Three astrolabes made by Allāhdād survive today. The only dated exemplar among these was produced in 975 AH/1567 AD, and is preserved today in the Salar Jang Museum of Hyderabad.[20] The other two, presumably made at about the same time, are now in the Billmeir Collection at the Museum of History of Science, Oxford.[21]

But we do not know of any celestial globe manufactured by the patriarch of the Lahore astrolabist family. The earliest celestial globe extant today was manufactured in 998 AH / 1589 AD, during the reign of Akbar by one ʿAlī Kashmīrī ibn Luqmān,[22] who is not a member of the Allāhdād family. Next in chronological order are the four globes created by Allāhdād's grandson Qāʾim, Muḥammad ibn Mulla ʿIsā between the years 1622 and 1637, i.e. during the reigns of Jahāngīr and Shāh Jahān. The first of these is at Stonyhurst College, Lancashire, UK. The earliest globe available in India is the one crafted by Qāʾim in 1047 AH/1637 AD. It is now in the Khuda Bakhsh Oriental Public Library, Patna.[23]

Qāʾim's brother, Muḥammad Muqīm is known through 32 astrolabes[24] and one celestial globe.[25] Muqīm's son, Ḥamīd made at least one globe in 1065 AH / 1655 AD, which is now in the Whipple Museum of History of Science, Cambridge, U.K..[26]

4. *Ḍiyāʾ al-Dīn Muḥammad*

The most prolific and versatile member of this family is, however, Ḍiyāʾ al-Dīn Muḥammad son of Qāʾim Muḥammad. Twenty-six astrolabes, produced by him between the years 1637 and 1680, are known today.[27] The last of these is not a conventional planispheric astrolabe but a very large universal astrolabe, invented originally by al-Zarqalū of Cordova in the 11th century. Ḍiyāʾ al-Dīn's *Zarqālī* astrolabe, measuring 555 mm in diameter, is the only specimen of its kind in India. It is now preserved in Sawai Jai Singh's observatory at Jaipur.[28]

More particularly, Ḍiyāʾ al-Dīn Muḥammad produced the largest number of Islamic globes attributable to a single instrument maker. We know of 14 globes manufactured by him in the years between 1645 and 1680. These are now scattered all over the world: five in the United Kingdom, three in India, two each in Egypt and the USA, and one each in Russia and Germany. (See the table below).

Celestial Globes by Ḍiyāʾ al-Dīn Muḥammad

1.	1055 AH/1645 AD	Columbia University, New York.
2.	1057/1647	Asian Museum, St. Petersburg.
3.	1058/1648	Private Collection, Patna.
4.	1060/1650	Victoria & Albert Museum, London.
5.	1064/1654	Aligarh Muslim University, Aligarh.
6.	1067/1656	Victoria & Albert Museum, London.

7.	1068/1657	Welsh Industrial & Maritime Museum, Cardiff.
8.	1068/1657	Museum of Islamic Art, Cairo.
9.	1070/1659	Museum of Islamic Art, Cairo.
10.	1071/1660	Staatliche Museen, Berlin.
11.	1074/1663	Royal Scottish Museum, Edinburgh.
12.	1074/1663	Museum of History of Science, Oxford.
13.	1087/1676	Archaeological Museum, Red Fort, Delhi.
14.	1090/1679	Time Museum, Rockford.

Again, the last of these is not a conventional celestial globe but an open-work sphere in which the spaces have been cut out, leaving the constellation figures and the great circles. The star positions are shown by holes filled with glass or mica. A light placed inside this globe would illumine the star points, constellation figures and the great circles. Thus this globe resembles the perforated brass lamp shades, the manufacture of which also began in Mughal times and still continues at Varānasi and Muradabad.[29]

The other thirteen conventional globes can be divided into two groups. Three of them show only the major or astrolabe stars. In no. 3 large inlaid silver points indicate some 20 star positions, while in nos. 11 and 13 engraved dots within small circles represent 60 and 92 stars respectively. The remaining globes, on the other hand, are highly complex ones, showing through inlaid silver points approximately 1018 star positions according to Ulugh Beg's tables. Furthermore, the outlines of 48 constellation figures, mentioned by Ptolemy, are finely engraved.

While the common practice in the manufacture of globes is first to make two hollow hemispheres and then to join them, the globes of Qāʾim Muḥammad and his son Ḍiyāʾ al-Dīn Muḥammad were cast in one single piece by *cire perdue* or lost wax process, which is more time consuming but artistically more challenging. During this process, large holes had to be kept open which were later closed with plugs of the correct size and the engraving was continued over them. Thus in most of these globes plugs can be seen near the north and south poles.

Savage-Smith describes almost all of Ḍiyāʾ al-Dīn's known celestial globes, save no. 5 which is at Aligarh. Therefore, this particular globe will be described more elaborately here.

4. *The Aligarh Globe*

While a number of Ḍiyāʾ al-Dīn's magnificient astrolabes are preserved in India,[30] only three of his globes are reported to be still in India. Of these three, the present whereabouts of no. 3 are not known; it was in private possession in 1935.[31] Globe no. 13 in the Archaeological Museum at Delhi is also a small piece showing only

Fig. 1 Aligarh Globe with stand

92 stars.[32] Therefore, no. 5 is the only globe available in India which contains the full complement of star positions and constellation figures.[33]

According to Nadvi,[34] this globe formerly belonged to a Ḥakīm of Rampur. Now it is in the library of the Ajmal Khan Tibbia College, Aligarh Muslim University (Fig. 1).

The globe measures about 122 mm in diameter and rests on a horizontal frame, where two mutually perpendicular rings must have been affixed vertically in order to represent the meridian circle and the prime vertical. These rings are now missing. The horizontal ring itself had broken into four pieces at the four indents and was later repaired by nailing copper strips at the broken places (Fig. 2).

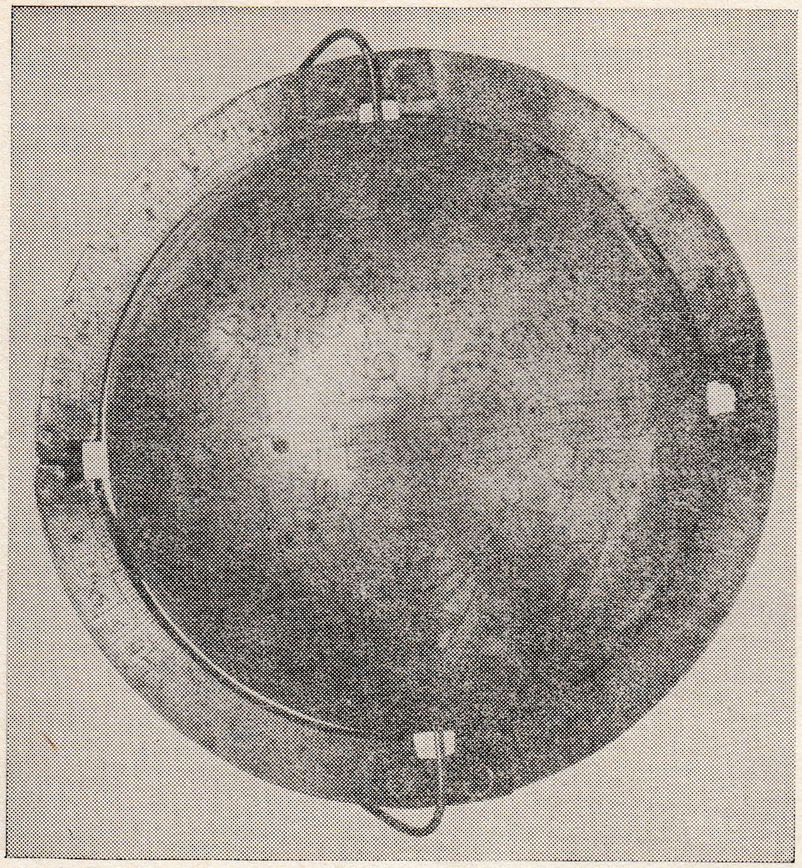

Fig. 2 Aligarh Globe: Horizontal Frame

In the globe there are two small holes at the two poles of the equator, through which the axis had passed originally, and was pivoted to the meridian ring. The axis is now missing and the globe is held above the frame by means of an iron wire. Close to each pole, there is a cicular patch or plug. The one near the north pole measures 29 mm and that near the south pole is 40 mm in diameter. The latter can be seen in Fig 3. The constellation figure of Centaurus extends over this plug. The equator and the ecliptic are marked by double bands of lines; one band is graduated in single degrees and the other in groups of five degrees and numbered (Fig. 4). Likewise the horizontal ring is also marked with a double band of lines. Single lines represent the tropics and the polar circles. Six great circles cut across the ecliptic perpendicularly and converge at its poles, thus dividing the globe into 12 segments or Zodiac signs (Fig. 5).

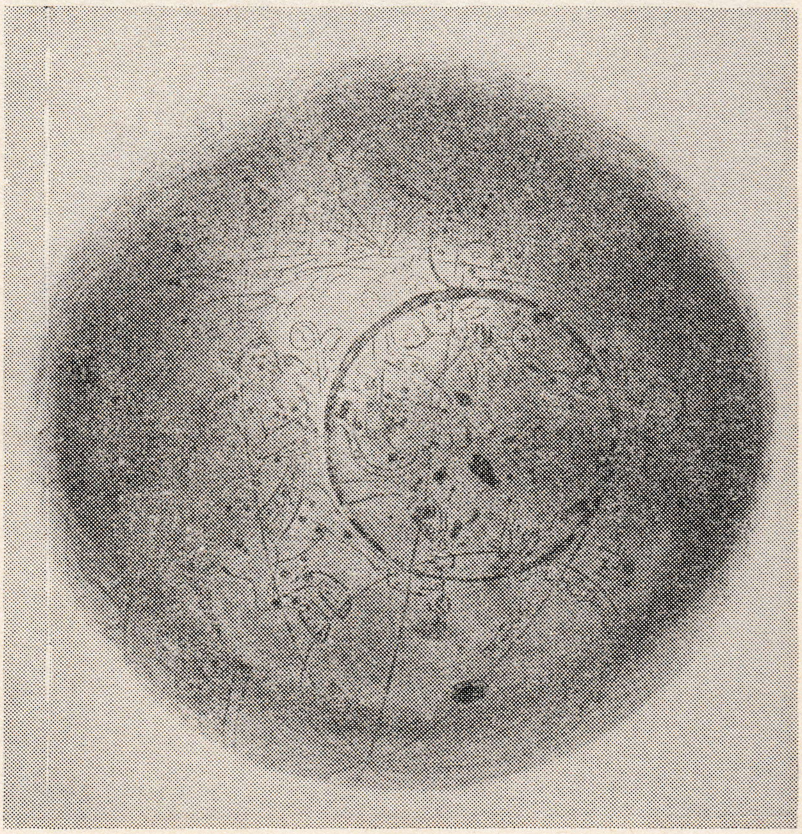

Fig. 3 Aligarh Globe: Plug near the South Pole

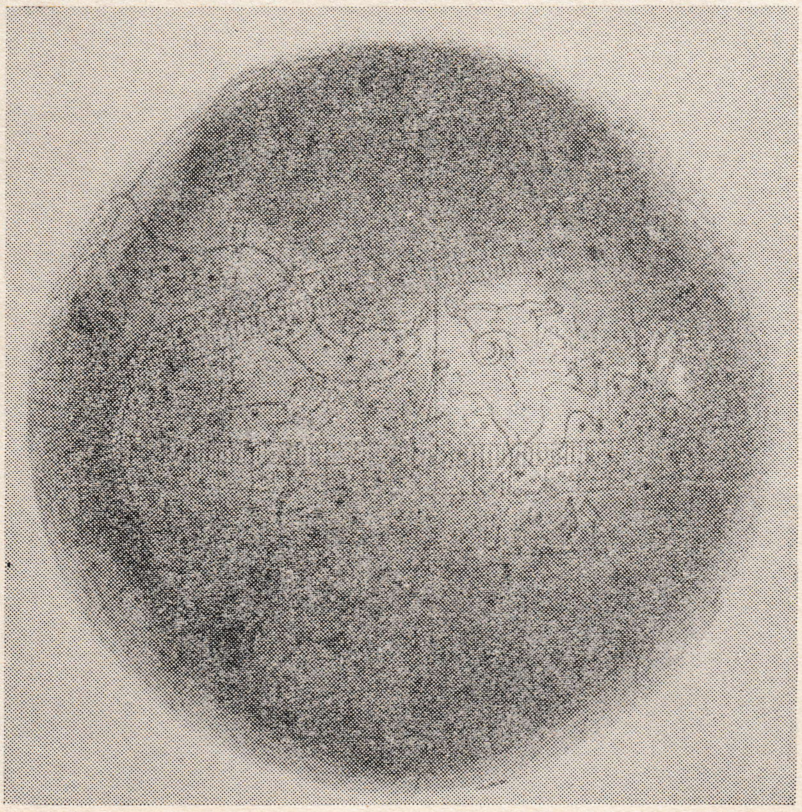

Fig. 4 Aligarh Globe: Ecliptic and Equator

About 1018 star positions are marked on the globe with inlaid silver points of three different sizes. The outlines of the 48 constellation figures and zodiac signs are meticulously engraved. Around the southern polar circle is the globe-makers inscription (Fig. 5), which reads as follows:

"The work of the humblest creature Ḍiyāʾ al-Dīn Muḥammad, son of Qāʾim Muḥammad, son of Mulla ʿIsā, son of S͟hayk͟h Allāhdād Asturlābī Humāyūnī Lāhorī, dated 1064 AH.[35]

6. *The Celestial Globe in Mughal Miniatures*

The long period of Ḍiyāʾ al-Dīn Muḥammad's creative activity, viz. from AD 1637 to 1680, encompasses the reigns of S͟hāh Jahān (1628-1658) and Aurangzeb (1658-1707). In S͟hāh Jahān's time the celestial globe had become popular enough to be depicted along with other astronomical instruments in two miniature paintings.[36] In

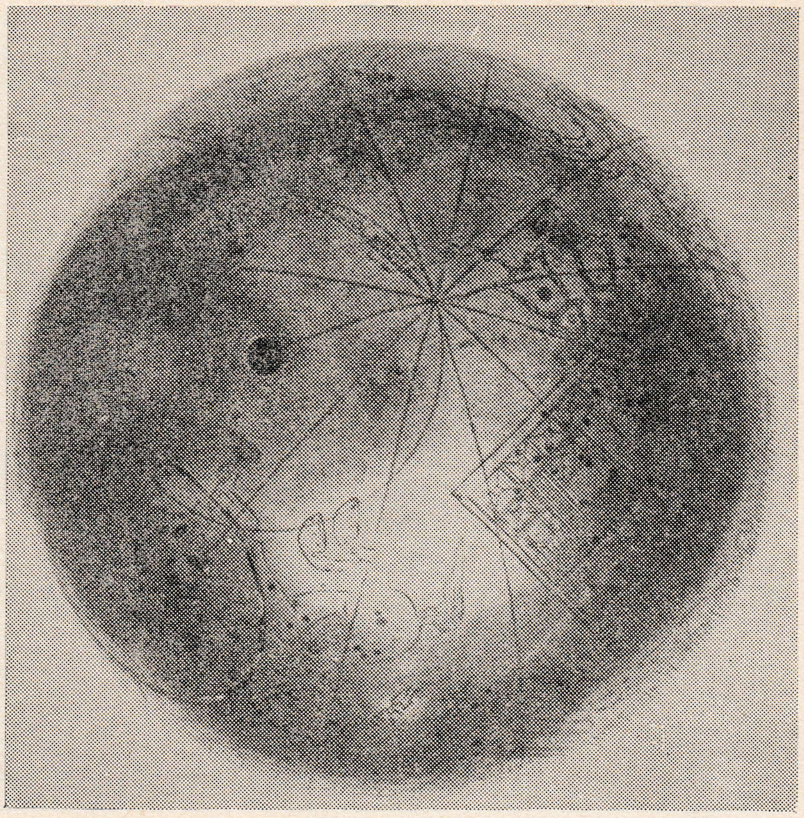

Fig. 5 Aligarh Globe: Maker's Signature within the Southern Polar Circle

both these miniatures, the astronomical instruments seem to transcend their physical function and acquire symbolic significance.

In the first miniature (Fig. 6), originally from an album made for Shāh Jahān and now in Musée Guimet, Paris, a venerable scholar is portrayed amid idyllic nature. He is surrounded by his pupils and three astronomical instruments: a celestial globe to his right, a small astrolabe in front of him and a sand clock to his left. The whole ambience suggests that he is not just a professional astronomer but a saintly recluse living far away from the bustle of mundane life and that the instruments are not mere measuring tools but emblems of secret knowledge which reveal the cosmic mysteries to this astronomer-philosopher.

The second miniature (Fig. 7) is from a series of portraits of his forefathers commissioned by Shāh Jahān and is now at the Smithsonian Institution, Washington. On the top margin of each portrait, two angels

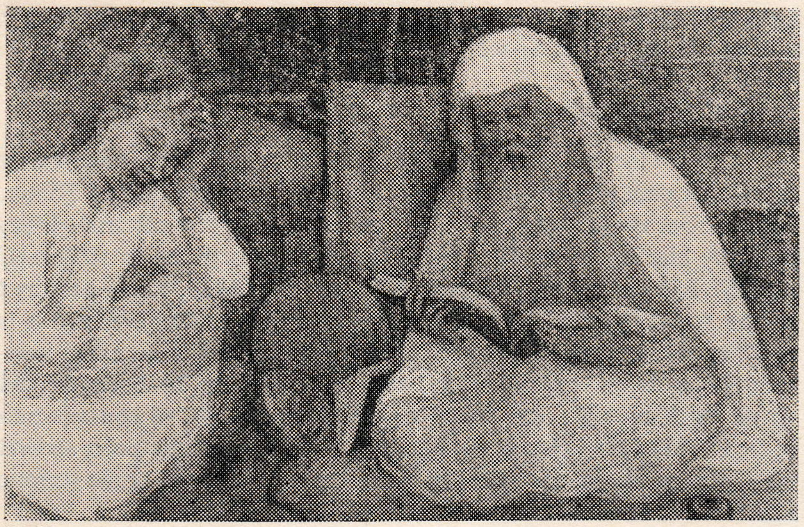

Fig. 6 Astronomer-Philosopher surrounded by Astronomical Instruments. Detail from a Mughal miniature.

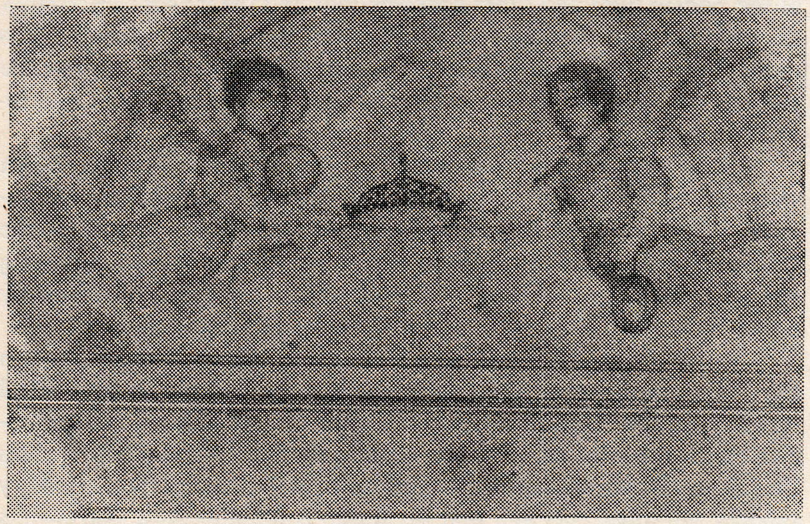

Fig. 7 Angels holding the Crown, Celestial Globe and Ring Dial. Detail from a Portrait of Humāyūn.

are depicted holding various kinds of symbolic objects. In the portrait of Humāyūn with which we are concerned here, two angels are holding a crown over Humāyūn, suggesting his universal sovereignty. Besides the crown, one angel is holding a globe, which can only be a celestial globe, and the other is holding a ring dial, both obviously as symbols of cosmic Space and Time.

7. *Other Globe-makers*

Outside the family of Allāhdād, we know of only one contemporary astrolabist cum globe-maker. This was Muḥammad Ṣāliḥ of Thatta, known from two astrolabes.[37] Till recently, only two celestial globes made by him were known. The first one was produced in 1070 AH/ 1659-60 AD for S͟hayk͟h ᶜAbdul K͟hāliq.[38] In 1928 it was acquired by the Archaeological Museum at the Red Fort of Dehi, where it is now preserved. It measures 210 mm in diameter and is mounted horizontally on a stand which is clearly a late addition. It shows the full set of 1018 stars through inlaid silver points and the 48 constellation figures. There are holes at the equatorial and the ecliptic poles so that the globe can be made to rotate around the equatorial or the ecliptic axis.

The other globe by Muḥammad Ṣālih was crafted in 1074 AH/ 1663 AD and is now in a private collection at London.[39] A remarkable feature of this globe is that the numbers on the scales, the names of the Zodiac signs and other constellations and the maker's inscription are given in both Arabic and Sanskrit (in *Devanagari* script). Two more globes, one signed by Ṣāliḥ and another unsigned but attributable to him, were noticed by the present author and his colleagues and reported elsewhere.[40]

Ṣālīḥ's globes were also cast by the *cire perdue* process, which was initiated by Qāᵓim Muḥammad and his son Ḍiyāᵓ al-Dīn Muḥammad. This tradition apparently continued up to the middle of the 19th century, though there are no extant globes cast in the intervening period. The last example of this tradition is a globe manufactured by Lālah Bahlūmal Lāhorī in 1842 for the ruler of Kapurthala.[41]

Aside from Bahlūmal, two others distinguished themselves in the 19th century with their keen interest in Islamic astronomical instrumentation. Nawāb Zayn al-ᶜĀbedīn of Delhi was a mathematician and instrument maker. His nephew Sir Syed Ahmad Khan writes that Zayn al-ᶜĀbedīn constructed beautiful globes, astrolabes, armillary spheres and quadrants and that his studio containing these instruments looked like an observatory.[42] Unfortunately, none of these instruments are extant.

Of course, in the 19th century, Muslim astronomers of India began to be acquainted with European astronomy and astronomical instruments. Such awareness can be seen in G͟hulām Ḥusain Jaunpurī's encyclopaedia *Jamiᶜ-i Bahādur K͟hānī* published from Calcutta in 1835. But the illustration of the celestial globe printed in this book[43] shows a traditional model. Indeed, a beautiful celestial globe manufactured by him in 1810 is in a private collection at Aligarh.[44]

These in brief are the Islamic celestial globes produced in India. There ought to be scores more, considering that the celestial globe, like the astrolabe, had been an important teaching aid for astronomy in the traditional *madrassahs*. Therefore, a thorough search needs to be undertaken, especially among Indian holdings.[45].

8. *Hindu Astronomers and the Celestial Globe*

What was the impact of this celestial globe on Hindu astronomers? It is, of course, not comparable to the astrolabe in its utility. Even so, it was noticed by Hindu astronomers even before Ḍiyāʾ al-Dīn's time. Nṛsiṃha Daivajña, hailing from a family of distinguished astronomers of Varanasi, wrote a commentary on Bhāskara's *Siddhāntaśiromaṇi* in 1621. In this commentary, he gives a detailed description of the celestial globe which he calls *bhagola*.[46] He explains that the Muslims obtain the star coordinates by direct observation and then mark these positions on the globe. He goes on to say that the Muslims call this instrument *kura,* and that the horizontal frame, which resembles the stand used by the Hindus for placing their sacred conch shell, is known as *kursī.*

The Hindu astronomers, however, did not make much use of this instrument. Consequently, there are very few extant specimens with legends written in *Sanskrit* language and *Devanagri* script. I have seen so far only three.

The first of these may have been made for Sawai Jai Singh and is now at the Hawa Mahal Museum, Jaipur (Fig. 8). Also at Jaipur, the Museum of Indology possesses a copper globe, on which just the ecliptic and the names of the Zodiac signs in Sanskrit are marked.

The third globe once belonged to David Eugene Smith,[47] the well known historian of mathematics, and is now in the Butler Library, Columbia University, New York. It is not signed nor dated, but Savage-Smith attributes it to the workshop of Lālah Bahlūmal Lāhorī of mid-nineteenth century.[48]

A vigorous search may yield a few more Sanskrit globes, but on the whole their number is nowhere near that of the Arabic/Persian globes produced in India, or for that matter, nowhere near the number of Sanskrit astrolabes. The reason is quite obvious. Hindu astronomers were interested in the coordinates of a very limited number of stars and not in all the 1018 stars marked on the celestial globe. Nṛsiṃha Daivajña says that only the lunar mansions and a few other

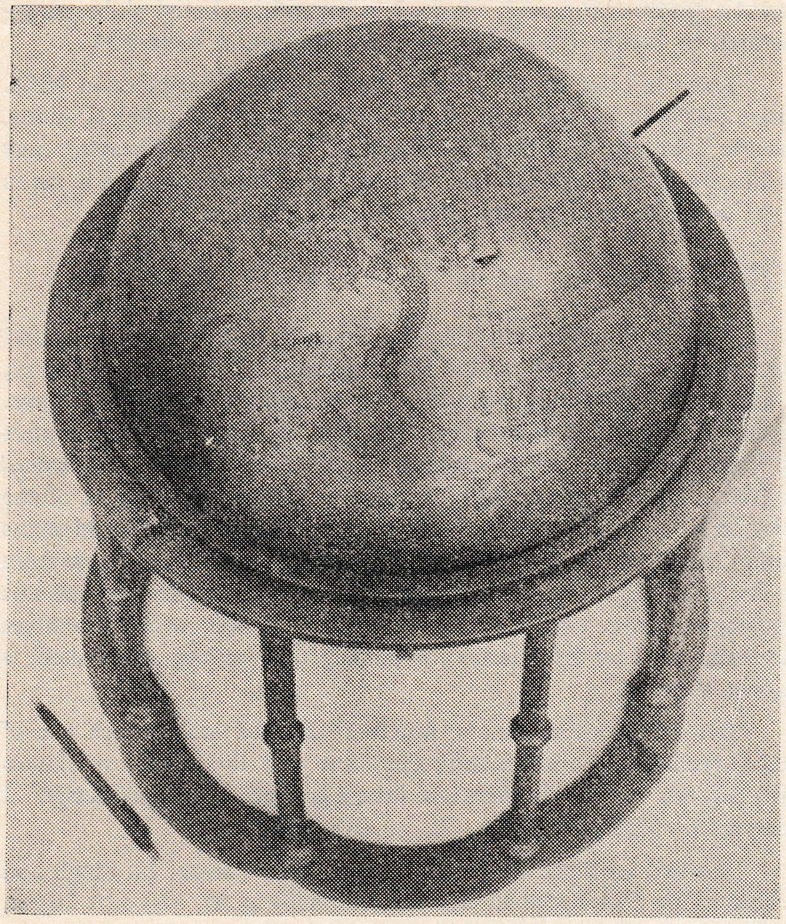

Fig. 8 Sanskrit Celestial Globe from Jaipur.

constellations like *Canopus* should be marked on the astrolabe. "Only these can be recognised by Hindu scholars. The stars known to the Muslims do not serve our purpose. Observation of unfamiliar stars would only lead to misfortune".[49]

The one person who tried to bridge this cultural gap was Sawai Jai Singh of Jaipur. In the 1730's he ordered a Sanskrit translation of Naṣīr al-Dīn al-Ṭūsī's Arabic version of the *Almagest,* including the description of the celestial globe[50]—a description with which in fact the history of this instrument commenced. Thus we have come a full circle, perhaps the proper thing to do in matters concerning the globe.

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* This paper was originally presented at the International Colloquium on Interaction of European and Asian Astronomy: Concepts and Instruments, organized by the International Astronomical Union, Commission 41, at Vienna in 1990.

1 King, pp. 4, 18.
2 Ibid, p. 4.
3 Lorch.
5 ESS, p. 214.
5 Seeman.
6 The present writer had the opportunity of seeing this remarkable globe at a special exhibition at Linz, Austria. It was described and illustrated in the catalogue of this exhibition, cf. Seipel, vol. II, p. 20.
7 Hartner, pp. 215, 221.
8 Sarma (a), pp. 69-71.
9 Nadvi, p. 269.
10 Beveridge, H., p. 123.
11 Ibid, pp. 283-84.
12 Beveridge, A.S., p. 51.
13 Beveridge, H., p. 445.
14 Sarma (b), pp. 238-241.
15 Sarma (e).
16 Raikva.
17 Blochmann, pp. 54-55.
18 Nadvi (a). pp. 621-631.
19 Emilie Savage-Smith, *Islamicate Celestial Globes. Their History, Construction and Use,* Washington, D.C., 1985.
20 CCA 1120.
21 CCA 1089 & 2530; Anderson, p. 35, no. 126.
22 ESS 10.
23 Nadvi (a), p. 627; ESS 14.
24 CCA, sv.
25 ESS 15.
26 ESS 68.
27 CCA, s.v.
28 Kaye (a), pp. 27-30; see also Sarma (d).
29 ESS 35, fig. 17.
30 Sarma (c).
31 Klueber.
32 Kaye (b), pp. 16-19.

33 Since writing this, I have located one more globe, dated AH 1074 (=AD 1663-64), in the Salar Jung Museum, Hyderabad. It will be described in my report on the instrument collection of this museum.
34 Nadvi, p. 628.
35 Ibid, p. 628.
36 Sarma (b), pp. 247-248; Pls. 6, 9.
37 CCA 23, 2502.
38 Dhama.
39 ESS 29, fig. 18.
40 Sarma, Ansari & Kulkarni, pp. 80-88.
41 ESS 33, fig. 24, p. 52 ff.
42 Nadvi (b), p. 269.
43 Jaunpuri, p. 515.
44 Ansari, S.R. Sarma & Kulkani, pp. 80-88.
45 The present writer commensed such a survey in 1991 and has catalogued the instruments in most of the collections in the US and UK and also of several museums in India, the reports of which are in preparation and will be published in the coming years.
46 Caturveda, p. 438.
47 For a drawing of this globe, see Smith, vol., II, p. 365, where it is assigned to ca. 1600.
48 ESS 54, fig. 25.
49 Caturveda, p. 449.
50 Sharma, vol. II, pp. 781-783.

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