Indian Journal of History of Science, **28**(1), 1993

TWO MUGHAL CELESTIAL GLOBES

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(Received 23 March 1992)

The celestial globe was an important astronomical instrument of the Middle Ages, both in Europe and in the Islamic world. It came to India rather late, probably in the middle of the 16th century during the reign of the Mughal emperor Humāyūn. Its manufacture began about the same time, but reached the high point in the next century, when the various members of the family of **Allāhabād, the master astrolabist of Lahore, produced several globes of great** workmanship. Indeed, of all the celestial globes extant today, the largest group emanates from this family.

Another Mughal instrument maker of note was Muḥammad Ṣāliḥ of Thatta (*fl.* 1659-67). Until now he is known only through three astrolabes and two globes.

This paper announces the existence of two new Mughal celestial globes. One is signed by Muḥammad Ṣāliḥ in the year 1073 AH, corresponding to AD 1662-63. The other, though without any signature, has a fair chance of being also his work. The paper describes these two globes against their historical background.

Next to the astrolabe, the celestial globe (Latin: *globus coelestis*; Arabic: *al-Kura*) was the most widely used astronomical instrument in pre-modern times. Hipparchus is said to have used it in the second century BC. Ptolemy, in the second century AD, devotes a whole chapter of his *Almagest* to its construction and use[1]. But it reached its fullest development only in the Middle Ages both in Europe[2] and in the Islamic world[3]. While the astrolabe is a versatile observational and computational instrument, the celestial globe is primarily a teaching tool, on which the apparent motion of the heavens and the relative positions of the fixed stars can be easily demonstrated.

Though there are some slight variations in its construction, the most common type consists of a spherical globe with the ecliptic, equator, tropics, polar circles, ecliptic latitude circles and other circles drawn upon it. Moreover, a large number of star positions are also marked on the globe according to the coordinates given either by Ptolemy (for the year AD 138), or by Ulugh Beg (for 841 AH/AD 1437-38), or as calculated by others, sometimes even by the globe-maker himself. Around specific clusters of stars are drawn constellation figures as conceived in Hellenistic mythology, or as modified later in the Islamic world. The *Almagest* describes 48 such constellations constituted by some 1018 fixed stars and enumerates the ecliptic coordinates and magnitudes of these stars[4]. Therefore, it was customary to draw 48 constellation figures and mark 1018 star positions, although there are globes with less number of stars.

At the two equatorial poles of the globe, holes are made for the axis to pass through, and this axis is pivoted inside a meridian ring, so that the globe rotates around the axis. The meridian ring is mounted perpendicularly upon a horizon ring which is supported by three or four legs. The axis can be so adjusted in the meridian ring that it is inclined to the plane of horizon by an angle equal to the terrestrial latitude of the place where the globe is to be used. Then the globe simulates the motion of the heavens above that place and the star positions on the globe correspond to those in the skies.

The manufacture of these globes was a highly specialized job, requiring great skill in metal work, engraving and calligraphy in addition to a good knowledge of astronomy. The surviving specimens, therefore, constitute a valuable part of a nation's scientific, technological and artistic heritage. The extant celestial globes of Islamic provenance were surveyed in an exemplary manner by Emilie Savage-Smith in her *Islamicate Celestial Globes: Their History, Construction, and Use*[5]. Unfortunately, she did not make a fresh survey of the specimens in India, but depended on file pictures and the scarce published notices with the result that there are lacunae in her account of the celestial globe in India[6].

In spite of its popularity in the Islamic world, where it was used in every *madarsa* for teaching astronomy (*'Ilm al-Haya't*), the celestial globe appears to be a latecomer to India[7]. It is mentioned for the first time in India in connection with the Mughal emperor Humāyūn (reign 1530-1556) who was reputed to be an expert in the use of the astrolabe and the celestial globe. Under his royal patronage, astrolabes and celestial globes began to be manufactured in India. Abūl Faẓl states in his *Ā'īn-i Akbarī* that Maulānā Maqṣūd of Hirat, a courtier of Humāyūn, manufactured excellent astrolabes and celestial globes[8], but none of these survived. The earliest known celestial globe emanates from the reign of Humāyūn's son Akbar (reign 1556-1605). It was made by one 'Alī Kashmīrī, son of Lūqmān, in 998 AH/AD 1589-90. Today, the globe belongs to a private collection in London. Apart from this single creation, no other information is available on the life and work of 'Alī Kashmīrī[9].

In this and the next century, several members of another family distinguished themselves as versatile and prolific manufacturers of astrolabes and celestial globes. The patriarch of this family, master Allāhdād of Lahore, was a near contemporary of Humāyūn, and is known for three astrolabes, one of which is dated 975 AH/AD 1567-68. But the earliest surviving celestial globes manufactured in this family are the four specimens made by his grandson Qā'im Muḥammad between the years AD 1622 and 1637[10]. Until then, celestial globes were made first as two concave hemispheres which were later joined at the line of equator. Qā'im Muḥammad perfected the technique of casting them as single hollow pieces by the *cire perdue* or lost wax process[11]. His son Ḍiyā' al-Dīn Muḥammad (*fl.* 1637-1680) excelled in this technique. Some 15 celestial globes crafted by him – the largest number ever known to have been made by a single individual – are preserved today in various parts of the world. He also made astrolabes of high artistic quality, of which more than 25 specimens exist in different collections[12].

Ḍiyā' al-Dīn's contemporary, Muḥammad Ṣāliḥ of Thatta (*fl.* 1659-1667), was also a notable instrument maker, though not so prolific as the former. So far, the following three astrolabes and two celestial globes made by him have been noticed.

Astrolabes

(i) Dated 1076 AH/AD 1665-66, with a diameter of 124 mm, and deposited in the East India Company Museum, London; (ii) dated 1077 AH/AD 1666-67, with a diameter of 194 mm, and deposited in the Billmeir Collection of the Museum of History of Science at Oxford; and (iii) in a private collection at Edgerton[13].

Celestial globes

(i) The first one, measuring 210 mm in diameter, was manufactured in 1070 AH/AD 1659-60 by the order of one Shaykh 'Abd al-Khāliq. It is now preserved in the Archaeological Museum at the Red Fort, Delhi. Some 1018 star positions are marked on it with inlaid silver points, and a number of constellation figures are engraved in outline. There are holes both at the poles of the equator and those of the ecliptic so that the globe can be made to rotate around the equatorial axis as well as the ecliptic axis. The original stand is lost, and the globe is now mounted horizontally on a non-functional stand[14].

(ii) The second known celestial globe by Muḥammad Ṣāliḥ was manufactured in 1074 AH/AD 1663-64, and is now in a private collection in London. This globe also exhibits the full complement of 1018 star positions marked by inlaid silver points and 48 constellation figures drawn in outline, besides the usual circles. It is mounted on a quadruped stand, with spindle-like legs, on a base formed by two crossbars. In the horizon ring there are two

notches for the meridian ring to pass through. To its underside is attached a semicircular arc as a support for the meridian ring. The original meridian ring, however, is missing, and is substituted by an ungraduated modern ring.

But the most interesting aspect of this globe is that it is bilingual. It contains the names of the zodiac signs, lunar mansions, and other constellations in both Arabic (Naskh script) and Sanskrit (Devanāgarī script). The graduations are also numbered in two systems. The ecliptic is graduated in single degrees and each fifth is labelled in Arabic and Devanāgarī numerals. The equator is also graduated in single degrees and each fifth is labelled in *abjad* notation on one side and in Devanāgarī numerals on the other. In the case of the horizon ring, however, each sixth is labelled in Devanāgarī numerals only[15].

Occasionally, the Sanskrit names are abbreviated, as there is not enough space for the full form. Thus, there are names of zodiac signs like *kuṃ. mū.* (for *kuṃbha-mūrti*, literal translation of *sūrat sākib al-mā'*, "figure of Acquarius"); *mī. mū.* (*mīna-mūrtī*, translation of *sūrat al-ḥut*, "figure of Pisces"); lunar mansions like *abhijit, śravaṇa, dhaniṣṭha, śatabhisā, pū. bhā.* (for *pūrvā bhādrapadā*)) and constellations like *aśvaskandha* (*faras a'ẓam*, Pegasus); *matsya mū(rti)*, (*al-dalfīn*, Dolphin), etc[16].

Near the south pole, there is a short inscription in Arabic to the effect that the globe was "the work of Muḥammad Ṣāliḥ Tatawī (in the) year 1074 (AH)." There is also a Sanskrit inscription, but Savage-Smith has not recorded the text. Even so, it is quite clear that Muḥammad Ṣāliḥ added the Sanskrit legends, so that the globe could be used not only by the Arabic-reading Muslim astronomers but also by those Hindu *jyotiṣīs*, who were interested in Islamic astronomy. Savage-Smith thinks that such clientele existed in the 17th century Kashmir and, for this reason, she wishes to assign Muḥammad Ṣāliḥ to Kashmir[17]. There is, however, no justification for this ascription. The Hindu *jyotiṣīs* who interacted with Islamic astronomy in the 16th and 17th centuries were mostly residents of Benares and/or were associated with the Mughal court at Agra, Fatehpur Sikri or Delhi[18]. To cite a few instances, some 40 years before Muḥammad Ṣāliḥ crafted the bilingual globe, Nṛsiṃha Daivajña of Benares described at length how Muslims constructed the celestial globe and marked the positions of the fixed stars upon it[19]. His son Kamalākara shows a great familiarity with Islamic astronomy in his *Siddhāntatattvaviveka* (1658). Again, in 1643, one Mālajit, who received the title Vedāṅgarāya from Shāh Jahān, composed at Agra his *Pāraśīprakāśa*, which contains a glossary of Arabo-Persian technical terms pertaining to astronomy and astrology, explained through the medium of Sanskrit[20].

It is for astronomers like these that Muḥammad Ṣāliḥ produced his bilingual globe. Whether he was born at Thatta in the Indus Delta or not, there cannot be much doubt about his place of activity being in the vicinity of the Mughal court

at Agra or Delhi, where he played the role of an intermediary between the Islamic and Hindu traditions of Astronomy.

Therefore, other creations by this Mughal instrument maker also deserve attention. We are happy to announce in this paper the existence of two new Mughal celestial globes: one was signed by Muḥammad Ṣāliḥ and the other has also a fair chance of being his work. We saw these two globes in January 1992 in a private collection at Bangalore. These are said to have been acquired somewhere in Rajasthan in 1991. In the following report, we shall call the signed globe A (Figs. 1, 2, 5) and the other one B (Figs. 3, 4, 6)

Globe A

It is a hollow seamless globe, cast as one single piece by *cire perdue* process, without any visible plugs. The diameter of the globe is 150 mm. On the globe, the celestial equator and the ecliptic are represented by double bands of lines. The narrower band is graduated in single degrees, while on the broader band groups of 6° are marked and numbered in *abjad* notation (see Fig. 2). The tropics, polar circles and those around the ecliptic poles are marked by single lines. The same is the case with the ecliptic latitude circles: these six great circles cut perpendicularly across the ecliptic and converge at its two poles. The solstitial and equinoctial colures are also represented by single lines. These two circles cut across the equator perpendicularly and converge at the two equatorial poles (see Fig.1).

In the other two globes by Muḥammad Ṣāliḥ and in the majority of the globes by his contemporary Ḍiyā' al-Dīn, the star positions are marked by inlaid silver points. But here they are indicated by engraved dots enclosed within small circles. This device appears also in two of Ḍiyā' al-Dīn's globes[21]. However, Ḍiyā' al-Dīn draws regular circles around the dots, whereas in the present globe the circles are irregular and appear to simulate the twinkling of the stars (see especially Figs. 5 and 6). The full complement of 1018 stars are represented in this manner. The outlines of all 48 constellation figures are executed meticulously. There is a dark finish on the surface of the globe. Against this background, the engraved star points, constellation figures and circles stand out clearly. The maker's inscription is inside the southern polar circle and reads as follows: *'amal Muḥammad Ṣāliḥ Tatawī 1073*, "The work of Muḥammad Ṣāliḥ Tatawī[22] (made in the Hijri year) 1073." This year corresponds to AD 1662-63.

The axis of the globe passes through the two equatorial poles and rests on the horizon ring. There are decorative endpieces at both sides of the axis. Like the equator and the ecliptic, the horizon ring also has two bands of lines. The narrower band is graduated in single degrees and the wider band in groups of 6° which are, however, not numbered (Fig.2). The horizon ring is supported by a

quadruped stand, having a height of 130 mm (Fig. 1). This stand resembles that of the bilingual globe just described. This one also has four spindle-like legs which stand on a base formed by two crossbars. However, there is a vital difference. There is no meridian ring and the axis of the globe is attached to the horizon ring. On the horizon ring, there are no notches to allow insertion of the meridian ring, nor is there a semicircular support below for the meridian ring. In this state, the axis of the globe cannot be adjusted for any local latitude save the terrestrial equator. It appears that the original horizon ring, the meridian ring and its support were either lost or damaged, and these were replaced later by a horizon ring which was graduated but not labelled and did not have any provision for the insertion of the meridian ring. The same is the situation with the stand of Globe B described below.

GLOBE B

The second globe is considerably larger. Its diameter measures 235 mm and the stand has a height of 210 mm (Figs. 3, 4). In all other respects, it closely resembles Globe A. The surface of this globe is much darker, almost black, and the engravings are much sharper. Unfortunately, however, this globe carries no maker's inscription. But a comparison of the two globes shows such exact correspondence that the conclusion is inevitable that Globe B is also a creation of Muḥammad Ṣāliḥ. Both globes have solstitial and equinoctial colures, which is somewhat rare in Indian globes, and the iconography of the constellation figures is exactly the same. Compare, for example, the constellation Argo Navis (Arabic: *al-safīnah*) near the south pole in both the globes (Figs. 5 and 6). Though there is some slight divergence in star positions, the ships look quite alike, so do the bearded figureheads on the left with the jaunty turban.

With the discovery of these two new globes, Muḥammad Ṣāliḥ's known oeuvre has risen to seven pieces: three astrolabes and four celestial globes. It is hoped that a fresh survey may reveal more creations of this Mughal instrument maker and throw further light on his life and work. While concluding this report, we should like to emphasize the urgent need for locating and documenting the scientific instruments manufactured in pre-modern times in India, before such instruments are lost for ever due to our neglect[23].

Fig. 1. Globe A with stand

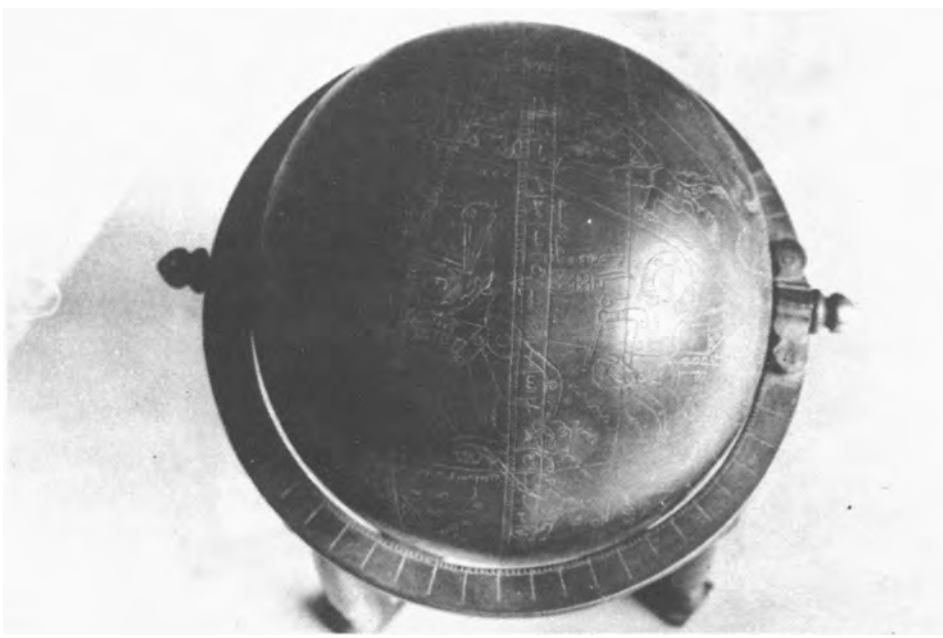

Fig. 2. Globe A with horizon ring. Note the equator at the middle of the globe. Libra to its left and Serpentarius to the right.

Fig. 3. Globe B with stand. Constellations of the northern hemisphere.

Fig. 4. Globe B with stand. Constellations of the southern hemisphere.

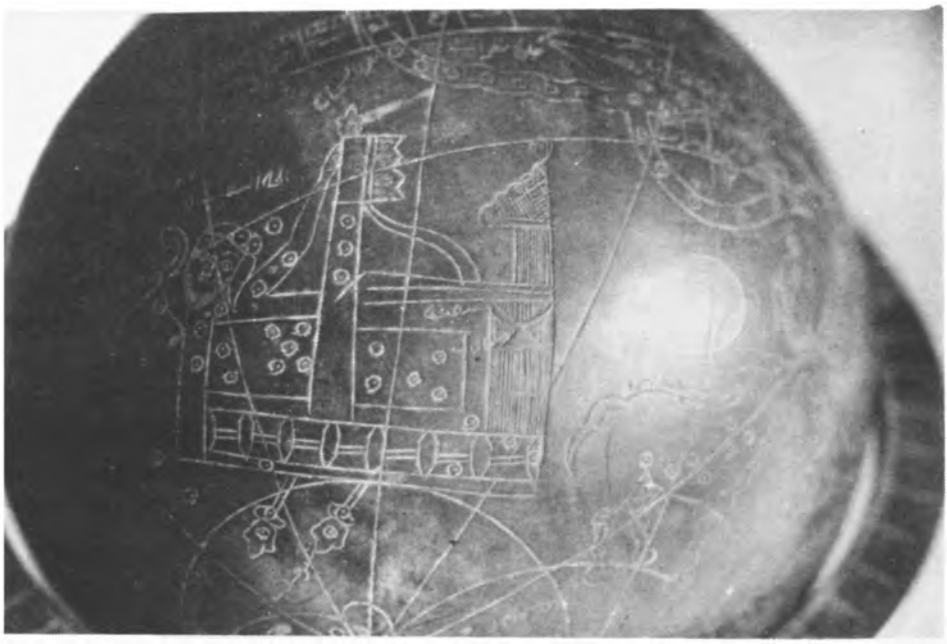

Fig. 5. Globe A, detail: Constellation Argo Navis.

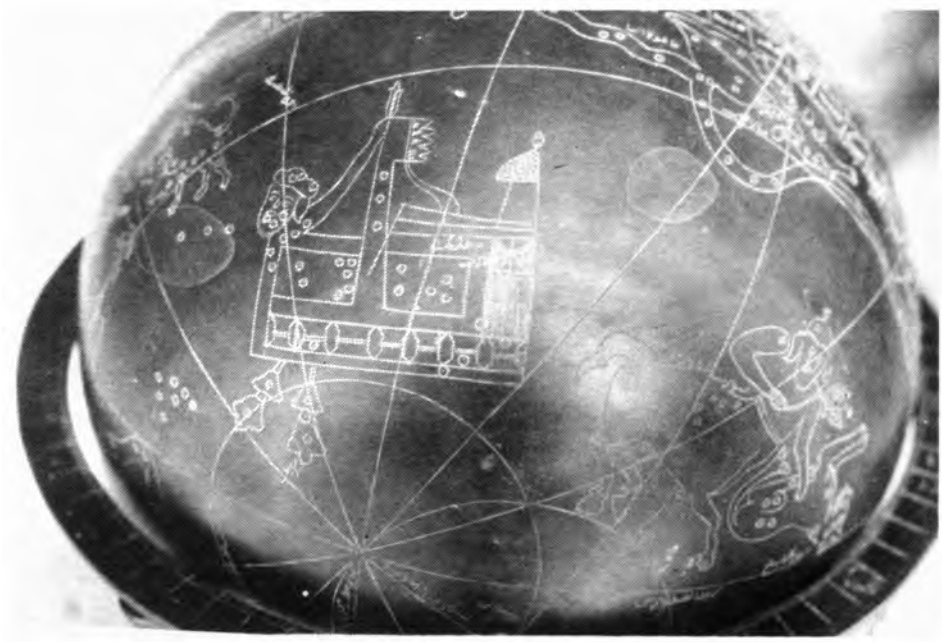

Fig. 6. Globe B, detail: Constellation Argo Navis with Centaur to the right.

NOTES AND REFERENCES

1. Book VIII, Chapter 3; cf. "The Almagest by Ptolemy," tr. R. Catesby Taliefero in: *Great Books of the Western World*, Vol. 16, Chicago, 1952, pp. 261-263; *Ptolemy's Almagest*, translated and annotated by G.J. Toomer, New York, 1984, pp. 404-407. For a Sanskrit rendering of this chapter, see Jagannātha's *Samrāṭsiddhānta*, ed. R.S. Sharma, Vol. II, New Delhi, 1967, pp. 781-783.
2. Cf. Zinner, Ernst, *Deutsche und Niederlaendische Astronomische Instrumente des 11-18. Jahrhunderts*, Munich 1979, pp. 168-178.
3. Cf. Wiedemann, E., s.v. al-Kura, *Encyclopaedia of Islam*, 2nd edn, Vol. V, p.397; David A. King, Astronomical Instrumentation in the Medieval Near East, in: idem, *Islamic Astronomical Instruments*, London, 1987, I, pp. 4, 18.
4. Cf. *Ptolemy's Almagest*, tr Toomer, pp 339-399.
5. Washington D.C. 1985. Henceforth cited as ESS. References are to the entry numbers of the globes surveyed, to the pages, or to the figures.
6. Interestingly enough, of the 50 signed globes described in ESS, as many as 26 are of Indian origin.
7. Cf. Sarma, Sreeramula Rajeswara, From al-Kura to Bhagola: On the Dissemination of the Celestial Globe in India, in: *Proceedings of the International Symposium on Interaction of European and Asian Astronomy, Vienna, 1990*, sponsored by IAU Commission 41 and Austrian Academy of Sciences (in press).
8. Ā'īn-i Akbarī tr. H. Blochmann, Vol. I, New Delhi, 1977, pp. 54-55.
9. ESS, No 10; pp. 34, 223-224; Figs 11, 68
10. ESS, No. 11-14; pp. 224-225
11. ESS, pp. 34-44, 90-95.
12. ESS, pp. 38-43; Sarma, *Op. cit.*
13. ESS, p 303, n. 158.
14. ESS, No. 25, pp. 229-230, B.L. Dhama, *Annual Report of the Archaeological Survey of India*, **28**, 143-144, 1928-29.
15. ESS, No. 29, pp 231-232.
16. ESS, Fig. 18 on p. 45.
17. ESS, p. 44.
18. Cf. Pingree, David Islamic Astronomy in Sanskrit, *Journal for the History of Arabic Science*, **2.2**, 315-330, 1978; Sreeramula Rajeswara Sarma, Astronomical Instruments in Mughal Miniatures, *Studien zur Indologie und Iranistik*, **16-17**, 235-276, 1992.
19. In his commentary (AD 1621) on Bhāskarācārya's *Siddhāntaśiromaṇi*, ed. Muralīdhara Caturveda, Varanasi 1981, p. 438. Cf. also Sreeramula Rajeswara Sarma, "From al-Kura to Bhagola..." (n. 7 above).
20. Cf Sarma, S.R., Islamic Calendar and Indian Eras in: G. Kuppuram and K. Kumudamani (ed), *History of Science and Technology in India*, Delhi, 1990, Vol. II, pp. 433-441.
21. ESS, Nos. 69 and 71, pp. 252-253. See also G.R. Kaye, *Astronomical Instruments in the Delhi Museum* (Memoirs of the Archaeological Survey of India, No. 12), Calcutta, 1921, pp. 16-19, Fig. 9.
22. Savage-Smith, p. 44, draws attention to the divergence in the spelling of this word in the globes discussed above. While it is written as "Tatawi" in the bilingual globe of 1074 AH, the word is spelt as "Tatah-wi" in the earlier one executed in 1070 AH.
23. Sarma, S.R. is currently cataloguing Indian astronomical instruments and welcomes information on extant specimens.