INTRODUCTION

A characteristic feature of Arab-Islamic astronomy during the Middle Ages is the promotion and tremendous growth of practical astronomy which was in turn manifested primarily by the establishment of scores of observatories in West-Central Asia, from Abbasid Caliph al-Mamun (813-833) to the Turkish king Murad III (1574-1595), and by the production of copious literature on astronomical Tables (the zîjes) as well as on astronomical instruments (alat al-rasad). The enormity of the literature on the latter could be gauged by the list of extant works as given by Matvievskaya and Rosenfeld (1983) in their recent Bio-bibliography: 349 treatises on astrolabes, 138 on sine-instruments, 81 on quadrants, 4 on sextants and octants, 41 on armillary spheres and celestial globes, 77 on sundials and again 77 on "other instruments"—in all 767 treatises. As a matter of fact the instruments developed by Arab-Islamic astronomers could be broadly classified into four groups: a) Time measuring instruments (e.g. sundials, shadow quadrants), b) Angle measuring instruments for astronomical parameters (e.g. armilla of various kinds, dioptric and parallactic rulers), c) instruments for transformation of system of coordinates and/or solving nomographical problems (e.g. astrolabes, quadrants, dastur instrument), d) Mathematical instruments for evaluating trigonometric functions, (e.g. sine-quadrants). Apart from the fourth and the most important of all, the astrolabe, which in turn embodies all the four groups of instruments to a certain extent, works on "other instruments" were compiled in almost every century (down from 9th to 18th A.D.), also by well-known Arab-Islamic astronomer-mathematicians. In order to stress the significance which the Arab-Islamic savants attached to astronomical instruments, we give here the following selected list:


Following the suggestion of Kennedy (1961) and Seemann (1928) we decided to study the work of al-Āmīlī and later found a similar work in the name of al-Qāyīnī. Their unique copies are extant at British Museum (London) and Mulla Firoze Collection at K.R. Cama Oriental Institute (Bombay) respectively. Our finding is that both monographs are surprisingly identical verbatim beginning with the descriptive text of the instruments, the introduction or preface being evidently different, see below. Moreover the monograph of al-Urđī (Seeman 1928) seems to be the source of the work in question. We intend to publish the full text with English translation elsewhere.

**THE MANUSCRIPTS**

The unique Ms of Ābdul Munim al-Āmīlī is extant at British Museum Persian Collection (Per. Add. 7702). It consists of 27 folios, size 8+1/2 x 6 inches, with 23 lines per page. On folio 1b, 6 lines from another beginning of the Ms are given, the last line is incomplete. The text of these lines does not agree exactly with the actual another beginning of the Ms which is on folio 2b (see the accompanying photograph 1) folio 2a is blank. It is clear from the photograph that the handwriting of f.2b does not tally with that of f.3a. The remaining folios of the Ms are in the latter handwriting (also noted by Seeman 1928). The title of the work does not appear in the introductory text; it is noted on the flyleaf or folio 1a: Kitāb taṣlīm al-ālāt-i
It is a bit unusual, since normally the Islamic astronomers used the term instruments of observation (alat-i rasad) rather than instruments of zij (the Tables). The name of the author appears at the end of 7th line of f.2b. In the colophon, the year of this copy of the Ms is given as 1112 A.H./1700 A.D.

Not much is known about al-\r{A}mil\r{I}. Suter (1900) did not give any biographical information about him. Matvievskaya & Rosenfeld improved upon Suter just a bit by referring to Sayili (1960) and Storey (1958, p.85). Sayili relied mostly on Seemann who on the basis of the note on the margin of f.2b dated the writing of the Ms as 970 A.H./1562-63 A.D. And therefore Seeman concluded that al-\r{A}mil\r{I} must have lived during the reign of Sh\r{a}h \r{a}h\r{a}m\r{a}sp I (1524-1576) - the second safavid king of Iran. However, the author of the manuscript explains in the text of f.2b, line 4 from below, the motivation of the king by the following words: "so that the riwaq of the capital of Isfah\r{a}n becomes like that of Alexandria, Mar\r{a}gha and Samarqand". Now, we may note that Sh\r{a}h \r{a}h\r{a}m\r{a}sp's capital was Qaz\r{w}in and only during Sh\r{a}h \r{a}bb\r{a}s I (1587-1629), Isfah\r{a}n became the capital of Safavid Kingdom. To be more precise, "Abb\r{a}s shifted from Qaz\r{w}in to Isfah\r{a}n in the year 1591 (Malcolm 1976; Fisher 1968). In other words, al-\r{A}mil\r{I} must have flourished and wrote, if at all, the tract in question after that year, i.e., at the close of the 16th century or beginning of 17th century.

Again, Q\r{a}sim \r{A}li \r{Q}ayini's manuscript is extant also as a unique copy at Mulla Firoze Collection in K.R. Cama Oriental Research Library, Bombay Ms No.1-21, described for the first time by Rehatsek (1873). The Ms consists of 98 pages, of size 7.4 x 4.9 inches, with 17 lines per page. The title of the work is given by Qayini as Jama\r{c} al-onwar min al-kawkab wa al-absar on f.1b last line; see photograph 2 and note in another hand writing the heading at the top: Suwar alat-i rasad\r{d}, i.e., diagrams of astronomical instruments. The name of the author is quite clear in the beginning of the 9th line, f.1b. In the colophon, the year is clearly given as 1100 A.H. (i.e. 1689 A.D.), which was, strangely enough, wrongly read by Rehatsek as 1000 A.H., i.e. 1592 A.D. (Storey 1958, p.89; Matvievskaya & Rosenfeld 1983, p.597). This manuscript is in an excellent handwriting, far better than that of al-\r{A}mil\r{I}.

Whereas Rehatsek has said nothing about Qayini, Storey gives a couple of biographical details about him, on p.89. On the basis of our own survey of Qayini's various works, particularly those extant in the libraries of Soviet Central Asia and Leningrad, we have succeeded in securing a bit more information about him.

Q\r{a}sim \r{A}li was a student of the fairly known astronomer and mathematician Mu\r{h}ammad Ba\r{q}ar ibn Zayn al-\r{A}bid\r{I}n al-Yaz\r{d}i (d. 1637) (Munzavi 1969, p.230, Foreword of MS.Serial No.2024), who was himself a disciple of Bah\r{a}u\r{d}d\r{a}n al-\r{A}mil\r{I} (1547-1622) (Matvievskaya & Rosenfeld 1983, 2, No.490, p.590). Qayini stated in the preface of one of his works that he learnt from al-Yaz\r{d}i the art of making astrolabe. Later, he occupied himself for quite sometime with the construction of astro-
labes, sine-quadrant. This statement of Qāyini is borne out by several of his extant tracts on the construction and uses of astrolabes. They are as follows: 1) Ms No.1/699 Sipahsâlar Library (Tehran), 40 ff, copied in 1672 by Sayfuddin Mâhmûd (Munzavi 1969, p.230). 2) Another Ms at Mawlânâ Muḥammad Ālî Library (Atak, Pakistan), 190 ff copied in 17th c. by Muḥ.Šâlîḥ (Munzavi 1983, p.238, Serial No.1401). 3) One in Mawlânâ Qadratullâh Personal Collection (Sargodha, Pakistan), 175 ff, copied in 1776 by Āḥmad Personal Collection (Munzavi 1983, p.238, Serial No. 1402). 4) Ms No. PNS 114, at State Public Library (Leningrad), 10 ff, ca. 1815-16. 5) Collection No.6400 in Majlis Library (Tehran), 40 ff, copied in 1840 by Ābdûljanî Īmâduddîn (Haeri 1972). 6) Ms. No.245 in the Library of Centre for Central Asian Studies (Sringar/Kashmir, India), 62 ff, copy of 1841 (Bhatt 1982). We have found this tract to be the only one of Qâyini's writings which is in Arabic. The title is Lub-i al-lubab fi Kayfiyya al-阵营 bi al-asturlâb. 7) Ms No.4/4061 in Majlis Library (Tehran), copy of 1847(Munzavi 1969, p.230). 8) Also Risalah Āsturlâb Zawraqî, Punjab University Library (Lahore, Pakistan), 9 ff, author's name given therein is Qâsim Ālî (Munzavi 1983, p.240, Serial No. 1420).

Besides the above listed works on astrolabe, Qâsim Ālî also wrote: 9) Risâlah dar ma'rifat-i Qibla, Majlis Library (Tehran), Ms. No.2/2377, copied in 1647, Munzavi 1969, p.331. 10) Risâlah dar Īlm-i Hay'at, Leningrad University Library, Ms. No.402(Matvievskaya & Rosenfeld 1983, 2, No.501a, p.597 entry A1). We have found an autograph copy of a Risalah Hay'at in Ms Collection of Ibn Sînâ Library at Bukhara, Ms. No.161 (new), copied in 1059 A.H./1650 A.D. This is a unique Ms with several marginal notes signed by Qâsim Ālî Qâyini, and has not been cited by Matvievskaya & Rosenfeld (1983). 11) Translation of Al-jabr wa al-Muqabla by al-Ṭusî, Ms No.2/13 19 at Tehran University Library, 54 ff, copied in 1671 by Râfî son of Muhammad Hasan Qâyini, (Munzavi 1969, p.148). 12) Tashrih dar Parqar, Ms 39 in Mashhad, copied 1656, with marginal notes in Qâyini's handwriting (Storey 1958, p.89). 13) Matla'i Hilaj, Ms. No.3/2377 at Majlis Library (Tehran), copied in 1682 (Munzavi 1969, p.351).

To this impressive list of Qâyini's works Jâmi al-Anwâr min al-Kawkab al-Abşar, copy of 1689, fits quite well as the culmination of Qâyini efforts for practical astronomy. But before we discuss this presumably last of his work, let us first settle the time when Qâyini flourished. On the basis of marginal notes in his works No.10 (Bukhara Ms) and No.12 (Mashhad Ms), it is clear that he was alive during 1650-56. On the other hand, Bâqâr Yazdî died in 1637 and therefore his pupil at the time of his death must not have been younger than 18 years of age, i.e., born in about 1619 A.D. Therefore when he wrote his first work on Qibla about 1645-47 he could be 26 years old and at the time of his last work in 1680-85 he could well be 60-66 years old. So roughly one may say that Qâyini flourished during 1620-1680.
THE AUTHORSHIP

To settle this question, let us note down the following facts.

Not a single work other than Kitāb ālāt-i zīj is known to have been written by ʿAbdul Mun'im al-ʿAmīlī. To write a general work on all astronomical instruments one is expected to be quite well-versed in the state-of-the-art. As listed in the introduction, there are very few general or comprehensive works on instruments. One is therefore justified to be skeptical about al-ʿAmīlī's authorship.

Further we find that in the last line of f. 1b, there is an abruptness in the text; see photograph 1. It is stated:

"...wa ghalaṭ wa sahl angārī zīj-i mazbūr maṯliūm ʿalāmyān gardad wa ālāt namā tiwānād kī mistār ālāt dhū shubatayn gardad".

That is, "... and the mistakes and omissions or carelessness of the afore-mentioned zīj [i.e. Zīj-i Ulugh Beg] could be known to the world and the ruler of triquetrum could not be the reason....." In other words the author abruptly switches on from the theme of previous compiled zīj to the astronomical instrument, the triquetrum. Comparing the texts of the two manuscripts we find that from the words: mistār ālāt dhū shubatayn onwards the two texts coincide verbatim, see photographs 1 & 2.

In contradistinction to what we have said above, the case of Qāyini as an author can be presented as follows. Since Qāyini had been a student of quite a well-known astronomer Muhīd. Baqar Yazdī, he became in a short time quite a bit of authority on the construction of a few instruments, like astrolabe and quadrant, in the first place. Further in his writings he has shown keen interest in the practical aspect of the instruments on which he also wrote quite substantially. Therefore it is evident that in the closing years of his life, he could write quite well a monograph on the construction and use of astronomical instruments in general.

Moreover one finds in his manuscript references to his various writings which are also extant in various libraries of the world, for instance No. 5, 9, of our list and Tashkent Ms, (See Note 3). Another interesting fact, which we have found out, is that the title of his monograph differs a wee-bit from the title of the philosophical work of his teacher al-Yazdī namely, maṭlaʿ al-anwar wa maṭlaʿ al-anẓār, (Matvilevskaya & Rosenfeld 1983, 2, No. 490, p. 590). One may interpret it as a kind of his dedication to the memory of his teacher. Consequently we think that ʿAbdul Mun'im just plagiarised it by replacing Qāyini's preface with his own. In fact the first draft of the first para of al-ʿAmīlī's preface is given on f. 1b which is different from what he wrote in the actual manuscript on f. 2b. It appears that al-ʿAmīlī just copied Qāyini's manuscript, from where Qāsim ʿAlī starts talking.
photograph 2: Folio 1b and 2a of Qāsim ʿAlī Qāyini’s Jāmaʿ al-anwār min al-kawkab wa al-ABSār (courtesy K.R. Cama Oriental Institute, Bombay).

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about the instruments, though strangely enough without understanding the text. We may add that the text of Qayini's manuscript on f.2b starting from the words *mistār alat-i dhu shu^c_batayn* fits quite well with the sentences which precede these few words. We are therefore of the opinion that the real author of this monograph on astronomical instruments was Qāsim ʿAlī Qāyini.

**CONCLUDING REMARKS**

For lack of time and space we confine ourselves only to the following remarks concerning the contents of Qāyini's tract: Without any definite chapterisation, the work begins after introductory remarks first with an account of the determination of the line of meridian by the method of *Indian circle*. Then follows a detailed description of the construction of various instruments, including methods of installation and of accuracy (*taššīh*). The instruments are: 1) *Dhāt al-rub°ca* (mural quadrant), 2) *Dhāt al-ṭalāq* (armillary sphere), 3) *ʿAlah-i ma^a_rifat-i mayl-i a′zām* (instrument for the determination of obliquity), 4) *Dhāt al-hadaf-i Sayyarah* (dioptre), 5) *Dhāt al-shucbatayn* (the parallactic rulers or triquetrum), 6) *Dhāt al-rub°ayayn al-ufuqiyah* (the double quadrants), 7) *Dhāt al-taẓhyi r* (the modifying instruments), 8) *Dhāt al-sahm wa-l-jayab*, 9) *Dhāt al-sahm wa-l-jayab*, 10) *ʿAlah-i Kāmilah* (the perfect instrument), 11) Celestial globe, in connection with the account of fixed stars.

Apart from the latter, this list of instruments coincides exactly with that of Muʿayyad al-Dīn al-ʿUrdī (fl. 13th c.), as given in his tract: *Risalah Kayfiyah al-Arsad* (Seeman 1928; Tekeli 1970), even the serialization of instruments is identical. Further, Qāyini's several diagrams of instruments agree closely with those of al-ʿUrdī. But his drawings and perspectives in both manuscripts (i.e., from British Museum and Mulla Firoze libraries) come through better than in al-ʿUrdī's tract.

On comparing Qāyini's & al-ʿUrdī's tracts, we have found the following mistakes. Qāyini has wrongly used the word *sahm* in No.8, instead of *samt* as in al-ʿUrdī's corresponding instrument. He exchanged the words *thuqbatayn* (two holes) with *shucbatayn* (two rulers) and vice versa, (See Notes 7 & 8). Further, whereas Qāyini's triquetrum is actually the parallactic rulers of Ptolemy, his instrument No.7 is the same as al-ʿUrdī's *dhāt al-ustuwanatayn*, fig.V in Tekeli's (1970) Arabic text, p.149 (See also Seeman 1928). Another mistake of Qāyini is regarding the name of the constructor or inventor of the "perfect instrument" (No.10). He attributes it to Najm al-Dīn, Wazīr of Malik Manṣūr, ruler of Ḥīmj. On the other hand al-ʿUrdī reports: "In the year 650 I constructed (camiltihū) another instrument for Malik al-Manṣūr, ruler of Ḥīmj in the presence (biḥudur) of Wazīr Najm al-Dīn....," (Tekeli 1970, Eng.Tr.p.93, Arabic p. 159). In fact we have compared a couple of instruments in the Arabic and Persian texts and have found them to be almost the same. Thus we conclude that the source of Qāyini is al-ʿUrdī's *Risalah*. As mentioned in the last section Qāyini quotes...
in his various works a couple of his predecessors or contemporaries, like his teacher Muhammad Baqar Yazdi and his son Mulla Muhammad Husayn (Munzavi 1969, p.230), also Muḥ. Taqī bin ʿAbb al-Ḥusayn Naṣīrī (Haeri 1972). It is not clear why he did not quote al-ʿUrūḍī as his source. Further light may be thrown on this question and the state-of-the-art of astronomical instrumentation by a detailed study of Qayinī's work. We intend to publish an English translation with edited text elsewhere.

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NOTES
1 On the margin it is recalled that "due to the precessional motion of the earth, mistakes crept in and can be found in the astronomical Tables of Ulugh Beg, Naṣīruddīn al-Ṭūsī and in the observations of Muḥīuddīn Maghrabī, al-Battānī, Chinese scholars, Jamshīd al-Kāshī." Stressing further that "in it a mistake was attributed to late Khwājā Naṣīr, it is nearly three hundred years from that time to writing and presentation of this treatise, that scholars took the text and presented it... and it got agreed to the deep-ocean like mind". Evidently this marginal remark is concerned with zijes, rather than astronomical instruments. And therefore it could not be attributed to al-ʿAmlī's work. Note that the enumeration of names is not chronological; the scribe was presumably not a scholar! We think that this note is just an addendum to the last line of the text (f.2b): ".....and the mistakes and carelessness of the above mentioned zij [i.e. of Ulugh Beg] could be known by the world". Further the difference of the hiḍra years of writing the Ms and that of the Ulugh Beg's Tables: 1112-842=270 = 300 years. Then the marginal note will agree well with the above-mentioned text as an additional remark.
2 Ms. PNS, 114 at the State Public Library (Leningrad) with the title Imtahan Asturlab, see f.1b.
3 Ms. No.465/IV at Institute of Oriental Studies (Tashkent), f.1b. Another incomplete copy Ms.No.5185/IX. This Ms is wrongly entered in the Tashkent Catalogue as on astrolabe.
4 This boat-like astrolabe was invented, in fact, by Abū Saʿīd Ahmad al-Sījī (fl.10th c.) as reported by al-Bīrunī, see Sezgin, 1978. A number of anonymous manuscripts on Asturlab Zawraqī are extant: Malikī Library (Tehran), Naṣī Library
He lists also the title Tashrih al-α c māl at Muṣlla Firoz Collection (Bombay) and another copy of 1680 at Qāḍī Ībāy Allāh Library (Madras) under Qāyini's writings. However, a manuscript Tashrih al-α c māl dar ｃ māl parkār-i mutanāsibah by Muḥammad Zamān Uṣṭrlābī Mashhādī, copied in India in 1862, exists in Raqā Library (Rampur) No.1163. And therefore Storey conjecture is questionable.

6 Munzavi notes that with this Ms are attached Qāyini's two other works: Qibla and Majla c al-ḥikam, the former may be the same as No.9 of our list.

7 Qāyini calls it also, though wrongly, dhāt al-shu c batayn instead of dhāt al-thuqbatayn, as it should be.

8 Again he names it wrongly dhāt al-thuqbatyn. He calls it also alāh-i ikhtilaf-i manzār.

9 Bombay Ms. f.42b, London Ms. f.23a.

REFERENCES


Fisher,W.B. (1968). The Cambridge History of Iran, ed. 1, 105-106


German translation of al-Ã–mili's preface, pp. 121-126; For English and Turkish tr. along with Arabic text See Tekeli (1970).


DISCUSSION

L.C. Jain: Have you included in your studies the works, 'Yantrarâja' and 'Yantrasiromani', probably of 13th and 15th Century A.D. respectively.

S.M.R. Ansari: I know the works; but I am not concerned at all with astrolabes.

S.Tekeli: As far as we know there is only one sextant described by Taqî al-Dîn. Can you call suds-i Fakhrî as a sextant?

S.M.R. Ansari: It is a question of definition, but the word suds means 1/6th = 60°. Isn't it?

S.N. Sen: Is there any instrument like the Râma Yantra found in Jai Singh's Observatory in the instrument list of Marâgha Observatory?

It is known that a few Chinese instruments makers worked at Marâgha under Nasîr al-Dîn's direction. Was the Chinese instruments making tradition imprinted in any way on the Arabic tradition?

S.M.R. Ansari: According to Samrât Siddhânta by Jagannâth Dhat al-Shu'datâyan (triquetrum) had been improved and replaced by Râm Yantra.

I may refer to Prof. Hartner's article on this topic.
S.N. Sen and S.P. Sarma (first row from left),
J.E. Kennedy and Mrs. J.E. Kennedy (second row from left)