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### 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-Māmūn (813-833) to the Turkish king Murād III (1574-1595), and by the production of copious literature on astronomical Tables (the *zījes*) as well as on astronomical instruments (*alat al-raṣad*). The enormity of the literature on the latter could be gauged by the list of extant works as given by Matvievskaia 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, dioptré and parallactic rulers), c) instruments for transformation of system of coordinates and/or solving nomographical problems (e.g. astrolabes, quadrants, *dāstur* 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:

In 9th c., al-Aṣṭurlābī, al-Kindī, Thābit Ibn Qurra, Sulaymān Ibn

<sup>c</sup>Iṣma; in 10th c., al-Khāzin, al-Sijzī, al-Khujandī, Ibn

al-Haytham; in 11th c., Ibn Sīnā, Abū al-Ḥasan al-Anṣārī; in 12th c.,

al-Khāzinī, Abū Naṣr al-Maghribī; in 13th c., al-Marrākushī

al-Abharī, al-<sup>c</sup>Urđī, <sup>c</sup>Alī Shāh al-Khwārizmī, al-Banna; in 14th c., Ibn al-Raqqām, al-Bukhārī, Ibn al-Shāṭir; in 15th c., al-Kāshī, al-Wafā'ī, Sibṭ al-Mārdīnī, Shamsuddīn al-Miṣrī, al-Humāwī; in 16th c., al-Barjandī, Ṭaqī al-Dīn, <sup>c</sup>Abdul Mun<sup>c</sup>im al-<sup>c</sup>Āmilī, Qāsim <sup>c</sup>Alī Qāyini; in 17th c., Ishāq Āfindī, al-Humaydī; in 18th c., Mahārājā Sawāi Jai Singh II; in 19th c., Ghulām Ḥusayn Jawnpūrī. For their various treatises one may refer to Matvievskaia & Rosenfeld (1983, Vol.II). However, one finds not many *general* treatises, wholly devoted to *all* astronomical instruments. To our knowledge they are only twelve works, namely by al-Khāzin, Ibn Sīnā, al-Khāzinī, al-Marrākushī, al-<sup>c</sup>Urđī, al-Kāshī, al-Barjandī, Ṭaqī al-Dīn, al-<sup>c</sup>Āmilī, Qāsim <sup>c</sup>Alī Qāyini, Sawāi Jai Singh and Ghulām Ḥusayn Jawnpūrī. The work of Jai Singh with the title *Yantraprakāra* is in Sanskrit though on Arabic instruments.

Following the suggestion of Kennedy (1961) and Seemann (1928) we decided to study the work of al-<sup>c</sup>Āmilī and later found a similar work in the name of al-Qāyini. 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-<sup>c</sup>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 <sup>c</sup>Abdul Mun<sup>c</sup>im al-<sup>c</sup>Āmilī 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 ta<sup>c</sup>līm alāt-i*

*zīj*. It is a bit unusual, since normally the Islamic astronomers used the term instruments of observation (*alat-i raṣād*) rather than instruments of *zīj* (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-<sup>c</sup>Āmilī. 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.<sup>1</sup> And therefore Seeman concluded that al-<sup>c</sup>Āmilī must have lived during the reign of Shāh Ṭahmāsp I (1524-1576) – the second safaavid 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 Iṣfahān becomes like that of Alexandria, Marāgha and Samarqand". Now, we may note that Shāh Ṭahmāsp's capital was Qazwīn and only during Shāh <sup>c</sup>Abbās I (1587-1629), Iṣfahān became the capital of Safavid Kingdom. To be more precise, <sup>c</sup>Abbās shifted from Qazwīn to Iṣfahān in the year 1591 (Malcolm 1976; Fisher 1968). In other words, al-<sup>c</sup>Āmilī 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, Qāsim <sup>c</sup>Alī Qāyini'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 Qāyini as *Jāma<sup>c</sup> al-anwār min al-kawkab wa al-abṣār* on f.1b last line; see photograph 2 and note in another hand writing the heading at the top: *Ṣuwar alat-i raṣādī*, 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-<sup>c</sup>Āmilī.

Whereas Rehatsek has said nothing about Qāyini, Storey gives a couple of biographical details about him, on p.89. On the basis of our own survey of Qāyini'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.

Qāsim <sup>c</sup>Alī was a student of the fairly known astronomer and mathematician Muḥammad Bāqar ibn Zayn al-<sup>c</sup>Ābidīn al-Yazdī (d. 1637) (Munzavi 1969, p.230, Foreword of MS.Serial No.2024), who was himself a disciple of Baha'uddīn al-<sup>c</sup>Āmilī (1547-1622) (Matvievskaya & Rosenfeld 1983, 2, No.490, p.590). Qāyini stated in the preface of one of his works that he learnt from al-Yazdī the art of making astrolabe<sup>2</sup>. Later, he occupied himself for quite sometime with the construction of astro-

labes, sine-quadrant<sup>3</sup> 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 Sipahsālār Library (Tehran), 40 ff, copied in 1672 by Sayfuddīn Maḥmūd (Munzavi 1969, p.230).. 2) Another Ms at Mawlānā Muḥammad<sup>c</sup> Alī Library (Atak, Pakistan), 190 ff copied in 17th c. by Muḥ.Ṣāliḥ (Munzavi 1983, p.238, Serial No.1401). 3) One in Mawlānā Quḍratullāh Personal Collection (Sargodha, Pakistan), 175 ff, copied in 1776 by Aḥmad<sup>c</sup> Alī Ḥasan (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<sup>c</sup> Abduljānī Imāduddīn (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 Qāyini's writings which is in Arabic. The title is *Lub-i al-lubab fī Kayfiya al-<sup>c</sup>aml bi al-aṣṭurlab*. 7) Ms No.4/4061 in Majlis Library (Tehran), copy of 1847 (Munzavi 1969, p.230). 8) Also *Risālah Aṣṭurlab Zawraqī*, Punjab University Library (Lahore, Pakistan), 9 ff, author's name given therein is Qāsim<sup>c</sup> Alī (Munzavi 1983, p.240, Serial No. 1420)<sup>4</sup>.

Besides the above listed works on astrolabe, Qāsim<sup>c</sup> Alī also wrote: 9) *Risālah dar ma<sup>c</sup>rifat-i Qibla*, Majlis Library (Tehran), Ms. No.2/2377, copied in 1647, Munzavi 1969, p.331. 10) *Risālah dar <sup>c</sup>Ilm-i Hay'at*, Leningrad University Library, Ms. No.402 (Matvievskaya & Rosenfeld 1983, 2, No.501a, p.597 entry A1). We have found an auto-graph copy of a *Risālah Hay'at* in Ms Collection of Ibn Sīnā 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 Qāsim<sup>c</sup> Alī Qāyini, and has not been cited by Matvievskaya & Rosenfeld (1983). 11) Translation of *Al-jabr wa al-Muqabla* by al-Ṭūsī, Ms No.2/1319 at Tehran University Library, 54 ff, copied in 1671 by Rafī<sup>c</sup> son of Muhammad Hasan Qāyini, (Munzavi 1969, p.148). 12) *Tashriḥ dar Parqār*, Ms 39 in Mashhad, copied 1656, with marginal notes<sup>5</sup> in Qāyini's handwriting (Storey 1958, p.89). 13) *Maṭla<sup>c</sup>-i Hīlaj*, Ms. No.3/2377 at Majlis Library (Tehran), copied in 1682 (Munzavi 1969, p.351)<sup>6</sup>.

To this impressive list of Qāyini's works *Jāmi<sup>c</sup> al-Anwār min al-Kawkab al-Abṣār*, copy of 1689, fits quite well as the culmination of Qāyini efforts for practical astronomy. But before we discuss this presumably last of his work, let us first settle the time when Qāyini 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, Bāqar Yazdī 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 Qāyini flourished during 1620-1680.

THE AUTHORSHIP

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

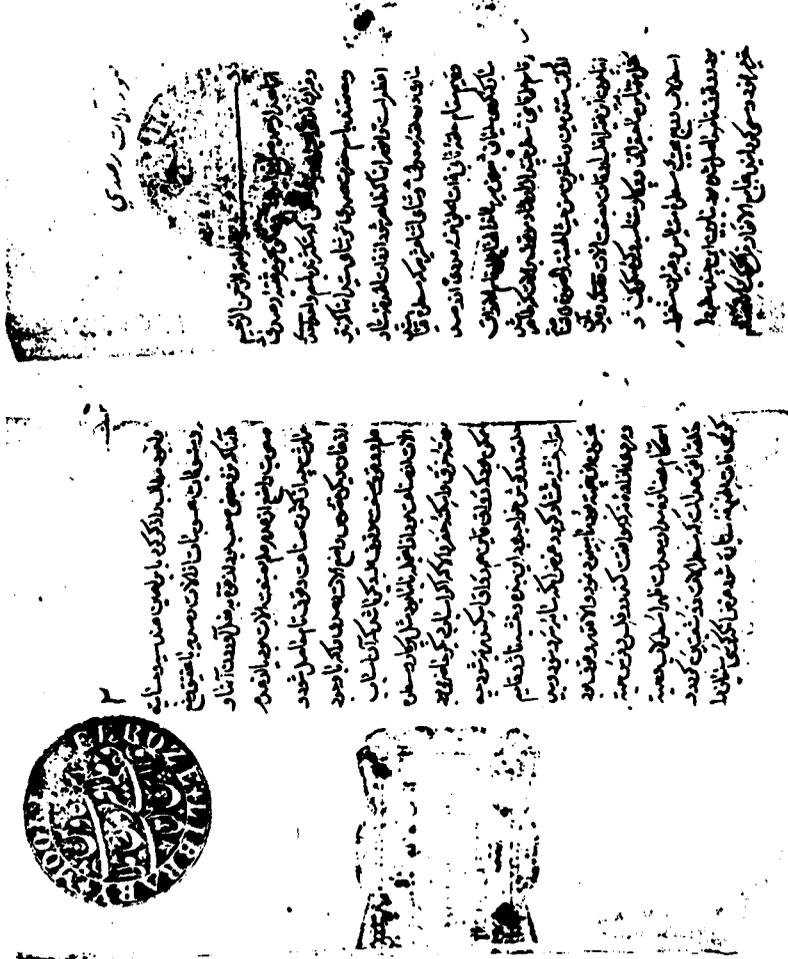
Not a single work other than *Kitāb ālāt-i zīj* is known to have been written by <sup>c</sup>Abdul Mun<sup>c</sup>im al-<sup>c</sup>Āmilī. To write a general work on all astronomical instruments one is expected to be quite well-versed in the state-of-the-art. As listed in the introduction, there are very few general or comprehensive works on instruments. One is therefore justified to be skeptical about al-<sup>c</sup>Āmilī'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 ma<sup>c</sup>lūm <sup>c</sup>ālamyān gardad  
wa <sup>c</sup>illat namī twānad ki miṣṭar ālat dhū shūbatayn gardad".

That is, "... and the mistakes and omissions or carelessness of the afore-mentioned zij [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: *miṣṭar ālat dhū shūbatayn* 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 Muḥd. 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, *maṭla<sup>c</sup> al-anwār wa maṭla<sup>c</sup> al-anṣār*, (Matvievskaya & 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 <sup>c</sup>Abdul Mun<sup>c</sup>im just plagiarised it by replacing Qāyini's preface with his own. In fact the first draft of the first para of al-<sup>c</sup>Āmilī'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-<sup>c</sup>Āmilī just copied Qāyini's manuscript, from where Qāsim <sup>c</sup>Alī starts talking





photograph 2 : Folio 1b and 2a of Qāsim <sup>c</sup> Ali Qāyini's *Jama* <sup>c</sup>

*al-anwār min al-kawkab wa al-absār* (courtesy

K.R. Cama Oriental Institute, Bombay).

about the instruments, though strangely enough without understanding the text. We may add that the text of Qāyini's manuscript on f.2b starting from the words *miṣṭar alat-i dhū shu<sup>c</sup>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<sup>c</sup> Alī 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 (*taṣṭih*). The instruments are: 1) *Dhāt al-rub<sup>c</sup>a* (mural quadrant), 2) *Dhāt al-ḥalaq* (armillary sphere), 3) *Alah-i ma<sup>c</sup>rifat-i mayl-i a<sup>c</sup>zam* (instrument for the determination of obliquity), 4) *Dhāt al-hadaḥ-i Sayyarah<sup>7</sup>* (dioptré), 5) *Dhāt al-shu<sup>c</sup>batayan* (the parallactic rulers or triquetrum)<sup>8</sup>, 6) *Dhāt al-rub<sup>c</sup>ayayan al-ufuqiyah* (the double quadrants), 7) *Dhāt al-taḡhyir* (the modifying instruments), 8) *Dhāt al-sahm wa-l-jayab*, 9) *Dhāt al-sahm wa-l-jayab*, 10) *Alah-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 Mu'ayyad al-Dīn al-Urdī (fl. 13th c.), as given in his tract: *Risalah Kayfiyah al-Arṣad* (Seeman 1928; Tekeli 1970), even the serialization of instruments is identical. Further, Qāyini's several diagrams of instruments agree closely with those of al-Urdī. But his drawings and perspectives in both manuscripts (i.e., from British Museum and Mulla Firoze libraries) come through better than in al-Urdī's tract.

On comparing Qāyini's & al-Urdī's tracts, we have found the following mistakes. Qāyini has wrongly used the word *sahm* in No.8, instead of *samt* as in al-Urdī's corresponding instrument. He exchanged the words *thuqbatyan* (two holes) with *shu<sup>c</sup>batayn* (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-Urdī's *dhat al-ustūwanatayn*, 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, *Wazir* of Malik Maṣṣūr, ruler of *hims*<sup>9</sup>. On the other hand al-Urdī reports: "In the year 650 I constructed (*amiltuhu*) another instrument for Malik al-Maṣṣūr, ruler of *hims* in the presence (*biḥudūr*) of Wazir 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-Urdī's *Risalah*. As mentioned in the last section Qāyini quotes

in his various works a couple of his predecessors or contemporaries, like his teacher Muḥammad Bāqar Yazdī and his son Mullā Muḥammad Ḥusayn (Munzavi 1969, p.230), also Muḥ. Taqī bin <sup>c</sup>Abd al-Ḥusayn Naṣīrī (Haeri 1972). It is not clear why he did not quote al-<sup>c</sup>Urḍī 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 Qāyīnī's work. We intend to publish an English translation with edited text elsewhere.

#### ACKNOWLEDGEMENT

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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-Ṭusī 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 *zīj*es, rather than astronomical instruments. And therefore it could not be attributed to al-<sup>c</sup>Amilī'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 *zīj* [i.e. of Ulugh Beg] could be known by the world". Further the difference of the *hijra* years of writing the Ms and that of the Ulugh Beg's Tables:  
 1112-842=270  $\approx$  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 *Imṭāḥan Astūrlab*, 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 Sa<sup>c</sup>īd Aḥmad al-Sijzī (fl.10th c.) as reported by al-Bīrūnī, see Sezgin, 1978. A number of anonymous manuscripts on *Astūrlab Zawraqī* are extant: Mālikī Library (Tehran), Raḡā Library

- (Rampur), Sālārjang Museum Library (Hyderabad). Mawlānā Dā'ūd Collection (Sargodha, Pakistan), Institute of Manuscripts (Baku, Azarbaijan). The latter is a copy of 1593.
- 5 He lists also the title *Tashrīḥ al-a<sup>c</sup>māl* at Mulla Firoze Collection (Bombay) and another copy of 1680 at Qādī<sup>c</sup> Ubayd Allāh Library (Madras) under Qāyini's writings. However, a manuscript *Tashrīḥ al-a<sup>c</sup>māl dar<sup>c</sup> amal parkar-i mutanasibah* by Muḥammad Zamān Usturlābī Mashhadī, copied in India in 1862, exists in Raḍā 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 *Maṭla<sup>c</sup> al-ḥikam*, the former may be the same as No.9 of our list.
  - 7 Qāyini calls it also, though wrongly, *dhāt al-shu<sup>c</sup>batayn* instead of *dhāt al-thuqbatayn*, as it should be.
  - 8 Again he names it wrongly *dhāt al-thuqbatayn*. He calls it also *ālāh-i ikhtilaf-i manẓar*.
  - 9 Bombay Ms. f.42b, London Ms. f.23a.

#### REFERENCES

- Bhatt,G.R. (1982). A Handlist of Arabic and Persian Manuscripts of the Research Library, Centre of Central Asian Studies, University of Kashmir, Srinagar.
- Fisher,W.B. (1968). The Cambridge History of Iran, ed. 1, 105-106
- Haeri,Abdol Hossain (1972). Catalogue of the Library of Majlis-i Shurā-i Millī, 19, Tehran, esp. p.555.
- Kennedy,E.S. (1961). Al-Kāshi's Treatises on Astronomical Observational Instruments, Journal of the Near Eastern Studies,20, 98-108; reprinted in Studies in the Islamic Exact Sciences, ed. D.A. King & Mary Helen Kennedy,Beirut, 1983.
- Malcolm,John (1976). The History of Persia, 1, 506, Tehran.
- Matvievskaya,G.P. & Rosenfeld,B.A. (1983). Matematiki i Astronomi Musul'manckovo Srednevekov'ya i ikh Trudi (8-17th Century), 3 vols, Moscow, See esp. 3, pp.147-152 for astronomical instruments.
- Munzavi,Ahmad (1969). A Catalogue of Persian Manuscripts, 1, Tehran.
- (1983). A Comprehensive Catalogue of Persian Manuscripts in Pakistan,Islamabad, 1.
- Rehatsek,E. (1873). Catalogue raisonné of Arabic, Persian, Hindostani and Turkish Manuscripts, Bombay, esp. pp.14-15.
- Sayili,A. (1960). The Observatory in Islam, Turkish Historical Society Series 7, No.38, Ankara; reprinted Arno Press, New York, 1981, esp. p.288.
- Seeman,H.G. (1928). Die Instrumente der Sternwarte zu Marâgha nach der Mitteilungen von Al-'Urḍī, Sitz. Ber. d. physik. Medizin. Soz, zu Erlangen, 60, 15-126. See esp. his

- German translation of al-<sup>c</sup>Ā-mīlī's preface, pp. 121-126; For English and Turkish tr. along with Arabic text See Tekelī (1970).
- Sezgin, F. (1978). *Geschichte des arabischen Schrifttums*, 6, Leiden, p. 224.
- Storey, C.A. (1958). *Persian Literature, A Bibliographical Survey*, Luzac & Co. London, 3 vols, in particular 2, Pt. I.
- Suter, H. (1900). *Die Mathematiker und Astronomen der Araber und Ihre Werke, Abhandlungen zur Geschichte der Mathematischen Wissenschaften*, Bd. X, published separately, from Leipzig. Reprinted by APA - Oriental Press Amsterdam. For al-<sup>c</sup>Ā-mīlī, see entry No. 473, p.192.
- Tekelī, S. (1970). *Al-Urdī'nīn "Risalet-ün fī Keyfiyet-il-ersad" Adli Makalesi, Araştırma*, 8, also issued separately, Ankara 1972, pp.169, Edited Arabic text with English and Turkish translation.

#### DISCUSSION

- L.C. Jain** : Have you included in your studies the works, 'Yantrarāja' 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.Tekelī** : As far as we know there is only one sextant described by Taqī al-Dīn. Can you call *suds-i Faḵhrī* as a sextant?
- S.M.R. Ansari** : It is a question of definition, but the word *suds* means  $1/6^{\text{th}} = 60^{\circ}$ . Isn't it ?
- S.N.Sen** : Is there any instrument like the Rāma Yantra found in Jai Singh's Observatory in the instrument list of Marāgha Observatory ?
- It is known that a few Chinese instruments makers worked at Marāgha under Nasīr al-Dīn's direction. Was the Chinese instruments making tradition imprinted in any way on the Arabic tradition ?
- S.M.R. Ansari** : According to Samrāt Siddhānta by Jagannāth Dhāt al-Shu<sup>c</sup>batayan (triquetrum) had been improved and replaced by Rām Yantra.

I may refer to Prof. Hartner's article on this topic.



S.N.Sen and S.R.Sarma (first row from left),  
J.E.Kennedy and Mrs.J.F.Kennedy(second row from left)