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research article

**Kharaqī's Star Catalogue:
A Star table from Medieval Arabic Astronomy¹**

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Abstract

In the Classical Islamic age, the star catalogues are highly influenced by Ptolemy's work. Nevertheless, Arab scholars were active in making amendments to *Almagest's* values. Studying these catalogues in their context related to Arabic astronomical traditions will shed some light on the historical evolution of the subject. This paper focuses on the star catalogues in *hay'a* tradition, specifically *Muntaha al-'idrāk fī taqāsīm al-'aflāk* (*The Utmost Attainment on the Divisions of the Orbs*), by 'Abd al-Jabbār al-Kharaqī (1084-1158 A.D.), which presents a relatively detailed star catalogue. We introduce this catalogue, identify its sources, and discuss its distinctive features.

Keywords: 'Abd al-Jabbār al-Kharaqī, *hay'a* works, *Muntaha al-'idrāk fī taqāsīm al-'aflāk*, Star catalogue, Ptolemy

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1. Introduction

The fixed stars and the planets are distinct topics in ancient astronomy, the first are characterized by their uniform motion and they are fixed relative to each other while the latter have complicated motions and they move related to each other. The main body of the most astronomical texts is devoted to the planets, providing theories and models for their motions, whereas the fixed stars principally serve as a system of reference for locating the planets. There was not a unique standard system for coordinates in premodern astronomy but the constellations along the ecliptic suggested the possibility of the ecliptic coordinate. In the Ptolemaic catalogue, given in the *Almagest*, the number of the fixed stars is 1022,¹ which are classified into 48 constellations (21 on the north of the zodiac, 15 on the south of the zodiac, and 12 on the zodiac). We should have in mind that in the ancient and medieval period, only a few comprehensive catalogues, which comprise all the names and information, were prepared; the other sources just represent a summary based on these comprehensive catalogues. The fact that most of the astronomical tables in Islamic periods are merely a reproduction of *Almagest* or some other accepted source is undeniable besides some evidence of new observations. Regardless of this distinction, we can classify the genres, including stars' information as below:²

- a) The tradition of *Šuwar al-Kawākib*: works belonging to this tradition take up 'Abd al-Raḥmān al-Šūfī's (903-986 A.D.) famous work;
- b) The *Almagest* tradition: redactions and commentaries of the *Almagest* constitute a vast tradition in medieval Arabic astronomy, which includes a reworking of the 7th and 8th books of *Almagest* concerning the fixed stars;

1. It is possible also to add three hidden stars called *Coma*; these three stars in Arabic text are categorized as "*hulbat*" which means the tail of Leo; the word chosen as the translation of Ptolemy Greek word "Plokamos" in Arabic texts is "*ḍafirāt*" which means braided hair: 'Abd al-Jabbār al-Kharaqī (2020, p. 90, paragraph [174]); Kunitzsch and Smart (2006, p. 41); Ptolemy (1984, p. 368, note 223); see also Kunitzsch (2002).

2. Kunitzsch (2008, pp. 2019-2020) provides a dichotomy (*Almagest* and instrumental tradition) that is not enough precise.

3/ Kharaqī's Star Catalogue...

- c) The books on the astrolabe: the Arabic works on the theory and use of the astrolabe include a part on those fixed stars which should be shown on the astrolabe plate;
- d) The astronomical tables or *Zījes*: a table of the fixed stars is an indispensable part of every *Zīj*. In the table, the star's coordinates and even its temperament were indicated.¹
- e) The *hay'a* tradition: a chapter on the fixed stars is an essential part of almost all *hay'a* treatises, which in most cases is a summary on the subject.

The status of stars in these traditions could be a matter of distinct research. However, regarding the recent publications of *hay'a* books, in this paper, we will study the fixed stars in *hay'a* tradition, principally in *Muntaha al-'idrāk fī taqāsīm al-'aflāk*, which was written by 'Abd al-Jabbār al-Kharaqī in 526-527 A.H./1132-1133 A.D. and containing a comprehensive fixed stars' catalogue.

This research addresses a subject at the intersection of two research literature: the historical survey on the fixed stars and the study of *hay'a* books. The most contribution to the survey on fixed stars in Arabic texts was by Paul Kunitzsch. His studies were initially about *Almagest's* fixed stars catalogue, then he extended his studies to the Arabic translation of *Almagest*. He also concentrated on the curious subject of Arabic star names in the catalogues.²

A survey on fixed star catalogues is an essential part of the history of astronomy in the Islamic classical age. The star catalogues provide us with information about the relationship between astronomical texts and observation in a specific period of time: which stars were a part of a standard catalogue in astronomy? Which stars' information was needed for an astronomer? Were the star catalogues updated due to

1. E.S. Kennedy (1956, p. 144).

2. For instance, see: Kunitzsch. P. (1959). *Arabische Sternnamen in Europa*. Wiesbaden: Harrassowitz; Kunitzsch. P. (1961). *Untersuchungen zur Sternomenklatur der Araber*. Wiesbaden: Harrassowitz; Kunitzsch. P. (1986-1991). *Claudius Ptolemäus: Der Sternkatalog des Almagest*, 3 vols. Wiesbaden: Harrassowitz; *The Arabs and the Stars*. (1989). Northampton: Variorum. [Variorum Reprints, Collected Studies Series, CS 307].

new observations? To answer all these questions concerning the Islamic classical age, more historical research should be accomplished, regarding that there are several textual and conceptual traditions dealing with fixed stars information.

The study of *hay'a* books was initially in the spotlight because of including some non-Ptolemaic planetary models, then the vast tradition of these books invited more researchers to work on them. As a result of these independent researches, now, the major works in this tradition are edited and some of them are published, for instance, *al-Tadhkira fī 'ilm al-hay'a* (*Memoir on Astronomy*), *al-Risālat al-Mu'iniyya*, and *al-Mulakhkhaṣ fī al-hay'a*.¹ These publications prepare the ground for a comparative study of the *hay'a* works: the gradual evolution of astronomical concepts is traceable in this tradition. Sections 2, 3, and 4 try to fill the gap in this intersection. Section 4 proposes a historical-astronomical method to date the works including fixed star catalogues. As an application, the writing date of al-Kharqī's *Muntaha* is estimated by this method.

2. Fixed stars section in *hay'a* tradition

The *hay'a* tradition was devised as a bridge between the *Almagest* planetary models and the Aristotelian image of the physical world, particularly of the heavens. The topics included in a typical *hay'a* book are as below:

1. Mathematical and natural principles
2. Configuration of the heavens
3. Mathematical geography
4. Distances and sizes of celestial bodies.²

1. Ragep, F.J. (1993). *Naṣīr al-Dīn al-Ṭūsī's Memoir on Astronomy (al-Tadhkira fī 'ilm al-hay'a)*. New York: Springer-Verlag; Ragep, S.P. (2016). *Jaghmīnī's Mulakhkhaṣ An Islamic Introduction to Ptolemaic Astronomy*. Switzerland: Springer; Naṣīr al-Dīn Muḥammad al-Ṭūsī. (2020). *al-Risāla al-Mu'iniyya and its Supplement*. Edited by Sajjad Nikfahm-Khubravan and Fateme Savadi with prefaces by F. Jamil Ragep and Hossein Masoumi Hamedani. Teharn: Miras-e Maktoob.

2. F.J. Rajep (1993, p. 36 introduction).

5/ Kharaqī's Star Catalogue...

Some of the fixed stars are generally introduced in the second part, but the extents and details of the list were not the same in all *hay'a* books.

In early *hay'a* works, that have been written in the 9th and 10th century A.D. -- Farghānī's *Jawāmi' 'ilm al-nujūm* (Chapter 19), Kūshyār's *al-zīj al-jāmi'* (the third book, 15th chapter), and *Fī hay'at al-'ālam* attributed to Ibn al-Haytham -- the fixed stars are considered as an autonomous topic that should be discussed independently:

Farghānī only mentions the classification of stars according to their magnitudes; he also gives a list of the fifteen brightest stars in the sky, which are considered to be of the first magnitude in this classification.¹ Kūshyār introduces the fixed stars before talking about the planetary motions in longitude.² However, in *Fī hay'at al-'ālam*, the main source of later *hay'a* works, the chapter on the fixed stars follows the chapters on the longitudinal motions of the planets. Here, the magnitude of the stars is mentioned as a criterion for their classification but the names of the constellations are not given.³

Only in some *hay'a* books, there is an explicit reference to the al-Şūfī's work, but it seems that in all cases, al-Şūfī is their original source: they repeat not only the same value for the rate of the precession (see section 4), but also the Arabic folkloric names of stars given by al-Şūfī.

Bīrūnī's *al-Qānūn* is not a *hay'a* work but it includes a comprehensive star catalogue in book 9,⁴ which could be a source for the successors. He compares Ptolemy's table to Şūfī's table and pays attention to the difference in magnitudes between the two tables. It is also known that Bīrūnī's Persian work on astronomy, *al-Taḥḥīm*, had a certain influence on the *hay'a* tradition. In this book, he calls the fixed stars "desert stars" (*ṣitārigān-i bīabānī*) and arranges them by name of constellations,⁵ the method which could be found in most *hay'a*

1. Alfarganvs (1669, pp. 74-76).

2. Kūshyār Jīlī (fols. 105r-106v).

3. Langermann (1990, pp. 61-63 Arabic text).

4. Bīrūnī (1954, pp. 1010-1126).

5. Bīrūnī (1988, pp. 89-98).

works. The naming shows that Bīrūnī in *al-Taḥḥīm* was thinking about the practical use of the stars, which is to find the way in the desert relying upon some well-known stars,¹ hence he is satisfied with naming the ecliptic south and north stars and he does not mention any specific details whereas, the text of *al-Qānūn* addresses professional astronomers who need a comprehensive catalogue to perform more detailed astronomical tasks.

From the 12th century A.D. onward, the *hay'a* tradition was established in its standard four parts structure. Among the *hay'a* works, Kharaqī's three independent treatises stand out for their breadth, clarity of exposition, and later influence:

- *Muntaha al-'idrāk fī taqāsīm al-'aflāk*, 526-527 A.H./1132-1133 A.D., 1444 Alexandrian (in Arabic)

- *al-Tabṣira fī 'ilm al-hay'a*, 526-527 A.H./1132-1133 A.D., 1444 Alexandrian (in Arabic)

- 'Umda-yi Khwārazmshāhī dar bayān-i badāyi'-i ilāhī, 536 A.H./1141 A.D., 1453 Alexandrian (in Persian)²

As we mentioned before in Bīrūnī's case, the sections devoted to the fixed star in these three works are not the same; it seems that their content and comprehension are adjusted according to their intended readers. The most comprehensive one is in the 12th chapter of *Muntahā*'s first book, which comes after the chapters on the description of the movement of planets in longitude,³ (see section 3). In *al-Tabṣira* and 'Umda, this section is in the final chapters of the first book, on the heavenly bodies: the 21st chapter of *al-Tabṣira* (the first book has 22 chapters) and the 24th chapter of 'Umda (the first book has 25 Chapters). In both books, this section comes before the chapter on lunar mansions.⁴

1. Bīrūnī (1988, p. 60).

2. For a short description of al-Kharaqī's works see. 'Abd al-Jabbār al-Kharaqī (2020, pp. 40-42 introduction).

3. 'Abd al-Jabbār al-Kharaqī (2020, pp. 75-110).

4. 'Abd al-Jabbār al-Kharaqī (*al-Tabṣira*, fols. 63v-66v); 'Abd al-Jabbār al-Kharaqī ('*Umda-yi Khwārazmshāhī*, fols. 39v-44r); 'Abd al-Jabbār al-Kharaqī (2020, pp. 319-350), that the lunar mansion comes in the 3rd book.

7/ Kharaqī's Star Catalogue...

al-Kharaqī's contemporary author, Sharaf al-dīn al-Mas'ūdī, wrote two books on *hay'a*: *al-Kifāya fī 'ilm al-hay'a* in Arabic and *Jahān-i Dānish* in Persian. In his introduction to *al-Kifāya*, he explicitly refers to *al-Tabṣira* as his source and model.¹ Not surprisingly, in both of his works, the fixed star section has the same position and format as in *al-Tabṣira*.²

In the 7th A.H./13th A.D. century *hay'a* books, the fixed star section gradually becomes more concise, and in some cases, for example, Jaghmīnī's *al-Mulkkhaṣ*, the section is completely eliminated.³ In the *hay'a* books belonging to the famous Maragha School, only the constellations and the number of their stars are mentioned.⁴ In these books, the information about the fixed stars is briefly stated because the knowledge of the fixed stars was then a separate discipline.⁵ In table (1), we give a list of *hay'a* works from 6th A.H./12th A.D. to 9th A.H./15th A.D. century and indicate the situation of the fixed stars chapter in these works.

Table (1): a list of *hay'a* works in 6-9 A.H./12-15 A.D. Centuries and the statue of the chapter on the fixed stars

Title	Author	Period	The number of chapters on Heavenly bodies	fixed stars Chapter's number
<i>Muntaha al-Idrāk fī Taqāsīm al-Aflāk</i>	'Abd al-Jabbār al-Kharaqī	526-527A.H./1132-1133 A.D.	20	12

1. Sharaf al-Dīn al-Mas'ūdī (*al-Kifāya*, fol. 107v).

2. Sharaf al-Dīn al-Mas'ūdī (*al-Kifāya*, fol. 131r-133r); Sharaf al-Dīn al-Mas'ūdī (2003, pp. 97-105).

3. S.P. Rajep (2016, p. 84 English translation and p. 85 Arabic text).

4. Naṣīr al-Dīn Muḥammad al-Ṭūsī (2020, pp. 51-59); F.J. Ragep (1993, pp. 128-129); Saliba (1990, pp. 375-393); Quṭb al-Dīn al-Shīrāzī (*al-Tuḥfa al-Shāhiyya*, fols. 26r-27v).

5. See. F.J. Ragep (1993, pp. 128-129) "Knowledge of the fixed stars and that which concerns them being a separate discipline." (و معرفة الثوابت و أحوالها فن مفرد)

Title	Author	Period	The number of chapters on Heavenly bodies	fixed stars Chapter's number
<i>al-Tabṣira fī 'Ilm al-Hay'a</i>			22	21
<i>'Umda-yi Khwārazmshāhī</i>		536 A.H./1141 A.D.	25	24
<i>al-Kifāya fī 'Ilm al-Hay'a</i>	Sharaf al-Dīn Mas'ūdī	549 A.H./1154 A.D.	22	21
<i>Jahān-I Dānish</i>				
<i>Al-Mulakhhaṣ fī al-Hay'a</i>	Jaghmīnī	602-603 A.H./1205-1206 A.D.	5	--
<i>Zubda al-Hay'a</i>	Nasīr al-Dīn al-Ṭūsī	Probably before 632 A.H./1235 A.D.	This book entirely has 30 chapters	5 ¹
<i>al-Risāla al-Mu'iniyya</i>		632 A.H./1235 A.D.	14	3
<i>al-Tadhkira fī 'Ilm al-Hay'a</i>		672 A.H./1274 A.D.	14	4
<i>Kitāb al-Hay'a</i>	Mu'ayyid al-Dīn 'Urḍī	Before 657 A.H./1259 A.D.	The book has numerous chapters and the section on the fixed stars is the last one	
<i>Nihāya al-Idrāk fī Dirāya al-Aflāk</i>	Quṭb al-Dīn Shīrāzī	680 A.H./1281 A.D.	13	4
<i>Ikhtiyārāt Muẓaffarī</i>				
<i>al-Tuḥfa al-Shāhiyya</i>				

1. Ghalandari (2007, pp. 52-57): al-Ṭūsī talks only on the two principal movements and do not mention to the constellations:

9/ Kharaqī's Star Catalogue...

Title	Author	Period	The number of chapters on Heavenly bodies	fixed stars Chapter's number
<i>Lubāb-i 'Iskandarī</i>	Ghīyāth al- Dīn Jamshīd Kashanī	Ca. 814 A.H./1411-1412 A.D. ¹	15	--
<i>Fārsī-yi Hay'a</i>	'Ala al-Dīn Qūshjī	9 th A.H. century/15 th A.D. century	6	3

The history of the fixed stars section in *hay'a* books, especially in the 6th and 7th centuries, shows how the authors' motivations and considerations affected the composition of their books. These motivations are of two kinds: first, as we see in Bīrūnī's work, a fixed stars section could be devised for practical use; thus, the constellation stars description is the main topic. Second, a fixed stars catalogue could be prepared for calculational astronomy, specifically *Zījs*. As for the considerations, they were also of two kinds: the *Hay'a* tradition is notably characterized as being influenced by Ptolemy's less known book, *Planetary Hypotheses*, which bestows them their principal characteristic: presenting a physical model of heavens without entering into the calculations. The second consideration is related to *hay'a* books intended public. Most of these books are written for educational purposes, so in most cases, the readers are students of science (to say nothing of the students of philosophy, theology, and even Islamic jurisprudence). The fact that some elaborated and innovative planetary models, such as al-Ṭūsī's couple, are introduced in the *hay'a* books for the first time shows that these books were also suitable for amateur astronomers. These motivations and considerations can explain why the fixed stars section was out of the

1. There are two versions of this treatise, one of them have entirely 20 chapters and another divided into three parts: an introduction, on the heavenly bodies (15 chapters) and on the configuration of the earth (12 chapters). See. Bohloul (2017, pp. 25-26); Nikfahm Khubravan and Savadi (2011, pp. 54-55).

scope of the Hay'a tradition and why it was eliminated gradually from these books.

3. al-Kharaqī's fixed star catalogue

3.1. al-Kharaqī's introductory points

The specific feature of al-Kharaqī's books is that, unlike the other *hay'a* books, they contain a comprehensive chapter on the fixed stars as well as a catalogue of the names, ecliptic coordinates, and magnitude of 84 stars. In *Muntaha* al-Kharaqī starts the section on the fixed stars with a discussion on the proper place for this section in a *hay'a* book:

We should discuss this sphere [i.e., the sphere of the fixed stars] either before the sun and other planets, because this sphere is above all of them, or after the sun and moon's spheres because it is possible to know the positions of the stars only after knowing those of the sun and the moon.¹

In this passage, he compares the two different places where a discussion of the fixed stars could be introduced. The first place respects the physical arrangement of celestial spheres, while the other place helps to provide a celestial coordinate system. al-Kharaqī's proposal could be understood as a critic of Ptolemy. He did not mention Ptolemy's name, but we know that the latter, in his *Almagest*, opts for the second place. Ptolemy wrote on the fixed stars in books 7 and 8, after having discussed the sun and moon's movement in the 3rd to 6th books, and before discussing other planets' movement in the 9th to the 12th books. Surprisingly, al-Kharaqī himself chose neither the first place nor the second one. He placed the fixed stars section after all these topics, arguing that the integrity of the subject of the celestial movements should be preserved.²

It seems that he is not content that Ptolemy disrupts the integrity of the subject by discussing motionless objects in the middle of moving objects, and also, he is not willing to respect the natural physical

1. 'abd al-Jabbār al-Kharaqī (2020, p. 75. Paragraph [142]).

من حق هذه الكرة أن تذكر إما قبل ذكر فلک الشمس وسائر الكواكب لاستعلائها على سائر افلاك الكواكب أو أن تذكر بعد الفراغ من ذكر فلکی النيرين إذ لا سبيل إلى معرفة شيء من أحوال الكواكب بالحقيقة إلا بمعرفة موضعي النيرين

2. 'abd al-Jabbār al-Kharaqī (2020, pp. 75-76. Paragraph [143]).

11/ Kharaqī's Star Catalogue...

arrangement of the world. However, in practice, regarding the significance of the movements of the planets, he completes the subject with a section on fixed stars sphere. However, in his two other works, *al-Tabṣīra* and *'Umda*, he even goes further by setting the fixed stars section as the last part of the book “on the heavenly bodies”.¹

al-Kharaqī continues to implicitly add another consideration to *Almagest*. He gives two reasons for these stars are called fixed: the first is because they are fixed reciprocally, which means the distance between them never changes; Ptolemy already mentions the reason in the 7th book of *Almagest*.² The other reason is that in the old times (*qadīm al-dahr*), people thought the stars do not move at all. As we know, Hipparchus, in the second century BC, was aware of the precession movement. Ptolemy says that “it would not be appropriate to call this [sphere] too fixed”³; probably because of this movement. It seems that the old times refer to the Babylonian period because the astronomers of the Greek period were usually called “the predecessors: (*al-mutaqaddimīn*). Bīrūnī only admits the first reason and states his objection by saying that it is the most suppositious reason (*awḥa al- 'ilal*), and we don't know who has invented it.⁴

al-Kharaqī arranges the 1022 fixed stars in 6 levels of magnitude and 48 constellations, as did Ptolemy and Ṣūfī, while he introduces Ṣūfī as his source. As al-Kharaqī acknowledges, his fixed stars catalogue is based on Ṣūfī's work so, we should expect only a reproduction of the same information. A comparison between his data and Ṣūfī's treatise shows that there are some points that could be investigated. In order to evaluate al-Kharaqī's dependence on Ṣūfī, we present a table comparing three principal books on his time available which could be available to him: *Ṣuwar al-Kawākib* as the direct, *Almagest* as the indirect, and Bīrūnī's *al-Qānūn* as a supplementary source. (See. Table 2)

1. Moreover, in these two works i.e., *al-Tabṣīra* and *'Umda*..., he brought the section of lunar mansion after the fixed stars at the end of the book “on the heavenly bodies” while in *Muntaha* this section comes in 3rd book “History”.

2. Ptolemy (1984, pp. 321-322).

3. Ptolemy (1984, pp. 321).

4. Bīrūnī (1954, vol. 3, p. 988).

Table (2): Number of constellation stars in main Islamic sources

		Number of constellation stars				
	Constellations	<i>Almagest</i>	Arabic translation of <i>Almagest</i>	Şūfi's <i>Şuwar al-kawākib</i>	Bīrūnī's <i>al-Qānūn</i>	Kharaqī's <i>Muntahā</i>
North of the Zodiac	Ursa Minor	7; 1 out ¹	7; 1 out	7; 1 out	7; 1 out	7; 1 out
	Ursa Major	27; 8 out	27; 8 out	27; 8 out	27; 8 out	27; 8 out
	Draco	31	31	31	31	31
	Cepheus	11; 2 out	11; 2 out	11; 2 out	11; 2 out	11; 2 out
	Bootes	22; 1 out	22; 1 out	22; 1 out	22; 1 out	22; 1 out
	Corona Borealis	8	8	8	8	8
	Hercules	28; ² 1 out	28; ³ 1 out	28; ⁴ 1 out	28; 1 out	29; 1 out
	Lyra	10	10	10	10	10
	Cygnus	17; 2 out	17; 2 out	17; 2 out	17; 2 out	17; 2 out
	Cassiopeia	13	13	13	13	13
	Perseus	26; 3 out	26; 3 out	26; 3 out	26; 3 out	26; 3 out
	Auriga	14	14	13 ⁵	14	14
	Ophiuchus	24; 5 out	24; 5 out	24; 5 out	24; 5 out	24; 5 out
	Serpens	18	18	18	18	18
	Sagitta	5	5	5	5	5
	Aquila	9; 6 out	9; 6 out	9; 6 out	9; 6 out	9; 6 out
	Delphinus	10	10	10	10	10
	Equuleus	4	4	4	4	4
	Pegasus	20	20	20	20	20
	Andromeda	23	23	23	23	22
Triangulum	4	4	4	4	4	
Total for the northern region		360	360	359 ⁶	360	360

1. "out" =outside of the constellation

2. Ptolemy, (1984, p. 349): at the end of the list, Ptolemy adds a description of a star which is on the end of the right leg of the constellation, but he did not count it because it is common to Bootes.

3. Kunitzch (1986, pp. 48, 49).

4. al-Şūfi (1986, p. 77) like Ptolemy have counted 29 stars in the description of the constellation and says that one of them is common to Bootes.

5. In the description of the constellation, al-Şūfi (1986, p. 117) refers to Ptolemy and says it has 14 stars but in the table, he mentions 13 stars (al-Şūfi, 1986, p. 124).

6. al-Şūfi (1986, p. 28): he said before that the total number of stars in the northern region is 360.

13/ Kharāqī's Star Catalogue...

		Number of constellation stars				
	Constellations	<i>Almagest</i>	Arabic translation of <i>Almagest</i>	Šūfī's <i>Šuwar al-kawākib</i>	Bīrūnī's <i>al-Qānūn</i>	Kharāqī's <i>Muntahā</i>
In the Zodiac	Aries	13; 5 out	13; 5 out	13; 5 out	13; 5 out	13; 5 out
	Taurus	33; ¹ 11 out	33; ² 11 out	32; ³ 11 out	34; 11 out	33; 11 out
	Gemini	18; 7 out	18; 7 out	18; 7 out	18; 7 out	18; 7 out
	Cancer	9; 4 out	9; 4 out	9; 4 out	9; 4 out	9; 4 out
	Leo	27; 8 out ⁴	27; 8 out	27; 8 out	27; 8 out	27; 8 out
	Virgo	26; 6 out	26; 6 out	26; 6 out	26; 6 out	26; 6 out
	Libra	8; 9 out	8; 9 out	8; 9 out	8; 9 out	8; 9 out
	Scorpius	21; 3 out	21; 3 out	21; 3 out	21; 3 out	21; 3 out
	Sagittarius	31	31	31	31	31
	Capricornus	28	28	28	28	28
	Aquarius	42; 3 out	42; 3 out	42; 3 out	42; 3 out	42; 3 out
	Pisces	34; 4 out	34; 4 out	34; 4 out	34; 4 out	34; 4 out
Total for the Zodiac		346 [350] ⁵	346 [350]	346 [349]	351	346 [350]
South of the Zodiac	Cetus	22	22	22	22	22
	Orion	38	38	38	40	38
	Eridanus	34	34	34	34	34
	Lepus	12	12	12	12	12
	Canis Major	18; 11 out	18; 11 out	18; 11 out	18; 11 out	18; 11 out
	Canis Minor	2	2	2	2	2
	Argo Navis	45	45	45	45	45
	Hydra	25; 2 out	25; 2 out	25; 2 out	25; 2 out	25; 2 out
	Crater	7	7	7	7	7
	Corvus	7	7	7	7	7

1. Ptolemy (1984, p. 363, note 192): Toomer mentions that 32 stars are true because one of the stars is recorded before as part of Auriga.
2. Kunitzch (1986, pp. 82-83; p. 86, note 11).
3. al-Šūfī (1986, p. 186): it seems to have counted 33 stars in the description of the constellation and says that one of them is common to Auriga.
4. Here we have 5 stars plus Coma (counted 3), which is not counted in the number of the Stars.
5. The sum of the stars of the list is 350 but since Coma and one of Taurus are not counted, then we have 346 stars.

	Constellations	Number of constellation stars				
		<i>Almagest</i>	Arabic translation of <i>Almagest</i>	Şūfi's <i>Şuwar al-kawākib</i>	Bīrūnī's <i>al-Qānūn</i>	Kharaqī's <i>Muntahā</i>
	Centaurus	37	37	37	37	37
	Lupus	19	19	19	19	19
	Ara	7	7	7	7	7
	Corona Australis	13	13	13	13	13
	Piscis Austrinus	12; ¹ 6 out	12; ² 6 out	11; 6 out	11; 6 out	11; 6 out
	Total for the southern region	316 [317] ³	316 [317]	316	318	316
	Total for all stars	1022 [1027]	1022 [1027]	1021	1029	1022 [1026]

As expected, the tables are almost the same; however, there are some dissimilarities:

- 1- About the two constellations, Hercules and Andromeda, situated on the north of the zodiac, al-Kharaqī is not in accord with Ptolemy and al-Şūfi.
- 2- About the constellation Taurus, situated on the zodiac, surprisingly, al-Kharaqī is in accord with Ptolemy and not with al-Şūfi.

These differences could be either al-Kharaqī's mistakes or innovation; for example, α And is common between constellations Andromeda and Pegasus and, it may be al-Kharaqī mistakenly counts this again in Andromeda. It likes the case of Taurus in Bīrūnī's *al-Qānūn*, which has two common stars with Auriga; However, Bīrūnī is much more different than al-Kharaqī from Ptolemy and al-Şūfi, so it could not be al-Kharaqī's reference. Hence, we can assume that al-Kharaqī also has another complementary source.

1. Ptolemy (1984, p. 399, note 155): Toomer mentions that 11 stars is true because one of the stars is recorded before as part of Aquarius.
2. Kunitzch (1986, p. 164,165).
3. The sum of the stars of the list is 317 but since one of Piscis Austrinus is not counted, then we have 316 stars

15/ Kharāqī's Star Catalogue...

al-Kharāqī's description of the constellations is so similar to al-Ṣūfī's that we can be sure that his main source was al-Ṣūfī. Subsequently, He presents his table consisting of 84 stars, which is, upon his own saying, a reproduction of al-Ṣūfī's table, with a correction related to the precession rate, a degree for 66 years (see section 4)

We registered the ecliptic longitudes and latitudes of some stars in the table for the beginning of the year 1444 Alexandrian, whose night altitudes are needed for Nativities (*mawālīd*) and other beginnings, endings, and prorogations (*tasyīrāt*) for detecting conditions such as the fortunate and unfortunate (*sa'd wa naḥs*).¹

al-Kharāqī introduces his criteria for the selection of these 84 stars, which are exclusively dictated by astrological purposes. Hence it can be compared to the star catalogue of astrolabe tradition, regarding that the astrolabes also were used for astrological practice. However, it seems that al-Kharāqī's list includes more stars than these treatises, as an example, Biruni's *'Istī'āb*, lists only 38 stars to be engraved on the astrolabe ecliptical ring. These 38 stars are already included in al-Kharāqī's catalogue.²

3.2. al-Kharāqī's table

The star table's format is principally similar in Ptolemy, al-Ṣūfī, and Bīrūnī. There are four columns: local description of the stars, ecliptic longitude, ecliptic latitude, and magnitude; the order is from the most northern constellation, Ursa Minor (*al-Dubb al-'Asghar*), to the most southern one, Piscis Austrinus (*al-Ḥūt al-Junūbī*). al-Kharāqī's table, for its 84 stars, has their names instead of local description, and the order is arbitrary. (See table 3)

1. 'abd al-Jabbār al-Kharāqī (2020, p. 99. Paragraph [197])

وقد أثبتت مواضع طائفة من جملة هذه الكواكب في الطول والعرض في جداول لأول سنة ألف وأربعمائة وأربعين من تأريخ
ذى القرنين مما يكتر الحاجة إليها في الارتفاعات الليلية للمواليد وسائر الابتدآت ومواضع الانتهاآت والتسييرات في معرفة الأحوال من
السعادات والنحوسات وغيرها

2. Bīrūnī (2001, pp. 35-50).

Table (3): al-Kharaqī's Star catalogue (for a critical edition: see appendix)

Number	Star name	Longitude	Latitude	Magnitude	Modern Identification
1	juday wa huwa dhanab al-dubb al-'aṣghar	Gem 15;7	N 67;0	3	α UMi
2	'anwar al-farqadayn	Leo 2;7	N 72;50	2	β UMi
3	'akhfā al-farqadayn	Leo 11;7	N 74;50	3	γ UMi
4	al-jawn	Leo 27;7	N 53;30	2	ε UMa
5	al-'ināq	Vir 2;57	N 55;40	2	ζ UMa
6	al-qā'id	Vir 17;46	N 57;0	2	η UMa
7	al-'ayyūq	Gem 9;57	N 22;30	1	α Aur
8	al-kaff al-khaḍīb	Ari 22;47	N 51;40	3	β Cas
9	al-nasr al-wāqī'	Cap 2;17	N 62;0	1	α Lyr
10	al-nasr al-Ṭā'ir	Cap 18;47	N 29;10	2	α Aql
11	al-ridf	Aqr 22;7	N 67;0	2	α Cyg
12	minqār al-dajājat	Cap 17;7	N 49;20	3	β Cyg
13	al-nayyir min al-fakkat	Lib 29;37	N 45;30	2	α CrB
14	al-simāk al-rāmiḥ	Lib 11;57	N 31;30	1	α Boo
15	mirfaq al-thurayyā	Tau 19;47	N 30;0	2	α Per
16	ra's al-ghūl	Tau 15;37	N 23;0	2	β Per
17	al-yad al-yumnā min barshāwūsh wa huwa al-suway'ad	Tau 11;37	N 40;30	Nebular	--
18	ra's al-hawwā wa yuqāl lah al-rā'ī	Sgr 9;57	N 36;0	3	α Oph
19	surrat al-faras	Ari 2;27	N 26;0	2	α And
20	janāḥ al-faras	Psc 27;7	N 12;30	2	γ Peg
21	mankib al-faras	Psc 17;7	N 31;0	2	β Peg
22	matn al-faras	Psc 11;37	N 19;40	2	α Peg
23	batn al-hūt	Ari 18;47	S 26;20	2	β And

17/ Kharāqī's Star Catalogue...

Number	Star name	Longitude	Latitude	Magnitude	Modern Identification
24	al-dabarān	Tau 27;37	S 5;10	1	α Tau
25	ra's al-taw'am al-muqaddam	Cnc 8;17	N 9;40	2	α Gem
26	ra's al-taw'am al-mu'akhhkar	Cnc 11;37	N 7;15	2	β Gem
27	al-mi'laf	Cnc 25;17	N 0;40	Nebular	--
28	qalb al-'asad al-falakī	Leo 17;27	N 0;10	1	α Leo
29	al-ṣarfāt	Vir 9;27	N 11;50	1	β Leo
30	al-simāk al- a'zal	Lib 11;37	S 2;0	1	α Vir
31	al-'anwar min al-zubānā al- junūbī	Sco 2;57	N 0;40	3	α Lib
32	al-'anwar min al-zubānā al- shumālī	Sco 23;50	N 8;50	2	β Lib
33	qalb al-'aqrab	Sco 27;37	S 4;0	2	α Sco
34	al-shumālī min al-thalathat 'allatī fī jabhat al-'aqrab	Sco 21;17	N 1;20	3	β Sco
35	al-wasaṭ minhā	Sco 20;37	S 1;40	3	δ Sco
36	al-junūbī minhā	Sco 20;37	S 5;0	3	π Sco
37	al-tālī li-jabhat al-'aqrab	Sgr 16;7	S 13;15	Nebular	--
38	'ayn al-rāmī	Cap 0;7	N 0;45	Nebular	--
39	fam al-ḥūt al- junūbī wa huwa al-ḍafda' al-'awwal	Aqr 21;57	S 23;0	1	α PsA
40	al-kaff al- jadh mā	Tau 2;37	S 17;20	3	α Cet
41	yad al-jawzā' al-yumnā	Gem 16;57	S 17;0	1	α Ori
42	mankib al- jawzā' al-yusrā wa yuqāl lah al-marzam	Gem 8;57	S 17;30	2	γ Ori
43	rijl al-jawzā' al-yusrā	Gem 4;47	S 31;30	1	β Ori

Number	Star name	Longitude	Latitude	Magnitude	Modern Identification
44	al-wasaʿ min al-mintaqat	Gem 12;16	S 24;50	2	ϵ Ori
45	al-rijl al-yumnā min al-jawzā'	Gem 15;7	S 33;30	3	κ Ori
46	ākhir al-nahr	Ari 15;7	S 53;30	1	θ Eri
47	al-shi'rā al-yamāniyyat wa hiya al-'abūr	Cnc 2;37	S 39;10	1	α CMa
48	al-shi'rā al-shāmiyyat wa hiya al-ghumaysā'	Cnc 14;7	S 16;10	1	α CMi
49	suhayl	Cnc 2;7	S 75;0	1	α Car
50	al-fard	Leo 14;57	S 20;30	2	α Hya
51	janāh al-ghurāb al-'ayman	Lib 1;37	S 12;30	3	γ Crv
52	rijl qantūris al-yumnā	Lib 23;17	S 41;10	1	α Cen
53	rijlih al-yusrā	Sco 11;47	S 42;20	2	β Cen
54	'amūd al-ṣalīb	Aqr 2;37	N 29;10	3	ϵ Del
55	qābiḍ al-thurayyā	Tau 20;17	N 27;50	4	σ Per
56	ḥajfalat al-faras	Aqr 20;27	N 22;30	3	ϵ Peg
57	al-'anwar min sa'd al-bahā'im	Psc 3;47	N 18;0	3	ζ Peg
58	dhanab qaytis	Psc 19;17	S 9;40	3	ι Cet
59	dābbat al-Simāk wa huwa aḥad kawkabay al-rumḥ	Lib 17;57	N 40;15	3	ϵ Boo
60	al-thānī min kawkabay al-rumḥ	Lib 6;17	N 28;0	3	η Boo
61	rijl al-'ayyūq	Gem 17;47	N 22;0	2	β Aur
62	rukbat al-rāmī	Cap 1;57	S 18;0	3	α Sgr

19/ Kharaqī's Star Catalogue...

Number	Star name	Longitude	Latitude	Magnitude	Modern Identification
63	al-dhīkh wa huwa dhakar al-ḍibā'	Vir 27;37	N 70;0	3	ι Dra
64	'aḥad al-dhi' bayn...	Vir 23;17	N 87;7	3	ζ Dra
65	al-thānī minhumā	Vir 24;57	N 78;0	3	η Dra
66	al-jāthī	Sgr 2;37	N 37;30	3	α Her
67	al-ḍafda' al-thānī	Psc 20;37	S 20;20	3	β Cet
68	'unuq al-ḥayyat	Sco 9;17	N 25;20	3	α Ser
69	aḥad kawkabay 'aḍud al-thurayyā	Tau 22;37	N 20;20	3	δ Per
70	al-thānī minhumā	Tau 21;47	N 21;50	4	ν Per
71	'ātiq al-thurayyā aḥad kawkabayh	Tau 19;7	N 12;0	3	ο Per
72	al-thānī minhumā	Tau 21;17	N 11;0	3	ζ Per
73	dhanab al-jady	Aqr 11;17	S 2;0	3	δ Cap
74	ra' s al-muthallath	Ari 26;57	N 16;30	3	α Tri
75	qarn al-thur wa huwa ka' b dhi al-'inān	Gem 10;37	N 5;0	2	β Tau
76	al-nāṭih	Ari 26;37	N 10;0	3	α Ari
77	zahr al-'asad	Leo 29;29	N 13;40	2	δ Leo
78	'urqūb al-rāmī	Cap 2;37	S 23;0	4	β Sgr
79	mankib al-'asad	Leo 17;7	N 8;30	2	γ Leo
80	rijl al-musalsalat wa huwa al-'ināq	Tau 1;47	N 28;0	3	γ And
81	kabid al-'asad bayn al-qā'id wa al-faqrāt al-'awlā	Vir 12;47	N 39;45	3	α CVn
82	aḥad kawkaby	Ari 25;57	N 16;30	3	α Tri

Number	Star name	Longitude	Latitude	Magnitude	Modern Identification
	al-'anīsayn				
83	al-thānī minhumā	Tau 0;57	N 20;40	3	β Tri
84	al-'ubayyiḍ	Ari 1;37	N 69;0	3	α Cep

3.3. The Table Comparison

In this section, we compare al-Kharaqī's catalogue to Ptolemy's and al-Şūfī's. We deemed it necessary because it is essential for connecting al-Kharaqī's list, based on star names to its source based on local descriptions. The result was to find some discrepancies.

3.3.1. On the star number 74

It is called the vertex of the triangle (*Ra's al-Muthallath*, α Tri), but its ecliptic longitude is different from α Tri. In the other row of the table, al-Kharaqī mentions the star α Tri as star number 82, called "one of the two companion stars" (*aḥad kawkabay al-anīsayn*) because this star and star β Tri form companions (*anīsayn*). The ecliptic longitude of No. 74 is Ari 26;57 while it is Ari 25;57 in No. 82 although, their ecliptic latitude (N 16:30) and magnitude (3) are the same. There is no better explanation than it could be the result of al-Kharaqī's mistake. In Arabic alphanumeric script, we would have ٢٦ for 26 and ٢٥ for 25. so those numbers could be confused

3.3.2. On the star number 62

The star magnitudes are not similar in *Şuwar al-kawākib* and *Almagest*; al-Şūfī wrote that he had edited magnitudes upon his observation, an observation made by the naked eye. The 76 of 84¹ stars have the same magnitude in *Şuwar* and *Almagest*. al-Kharaqī, for five of the eight remaining stars, expectedly, mentions the magnitude presented by al-Şūfī. The three other stars, two of them are according to Ptolemy, and the third has a different magnitude of both, indeed the magnitude of this star, α Sgr, is al-Kharaqī's own report (see Table 4). Its magnitude is two in *Almagest*, four in *Şuwar*, and three in *Muntaha*.... The star brightness is altering gradually over time in a way that is detectable by the naked eye. On the other hand, magnitudes are subjective in a way that latitudes and longitudes are

1. al-Şūfī (1986, p. 32)

21/ Kharaqī's Star Catalogue...

not. In this case, it seems that Ptolemy's report was not accurate, so al-Şūfi tried to replace a suitable magnitude in comparison with other stars. al-Kharaqī found al-Şūfi's magnitude excessive so he presents the magnitude between Ptolemy's and al-Şūfi's magnitude. Regarding that the star magnitudes are subjective values; the revision of these values is an interesting part of star tables.

Table (4): discrepancies between al-Kharaqī, Ptolemy, and Şūfi in star magnitudes

Number	Modern Identification	Kharaqī	Ptolemy	Şūfi
3	γ UMi	3	2	3
23	β And	2	3	2
31	α Lib	3	2	3
32	β Lib	2	2	3
54	ϵ Del	3	3	4
62	α Sgr	3	2	4
75	β Tau	2	3	2
78	β Sgr	4	2	4

3.3.3. On the star number 51

There is an erratum about star number 51. On the constellation Corvus, we have two stars on the left-wing (*janāḥ al-ghurāb al-'ayman*) and right wing. Kharaqī mistakenly registers the left star's ecliptic coordinates for the star on the right.

However, some discrepancies in latitudes are found in the comparison between *Muntaha* and *Şuwar*, and *Almagest* (see Table 5). The source of the discrepancies is not readily identifiable; it could be produced by a range of different probable causes, from scribes' inexactitude to an unknown source of Kharaqī's, i.e. it is possible that Kharaqī profited from another star table than Şūfi's.

Table (5): discrepancies between Kharaqī, Ptolemy, and Şūfi in star latitudes

Number	Modern Identification	Kharaqī	Ptolemy	Lat. Şūfi
1	α UMi	N 67;0	N 66	N 66
6	η Uma	N 57;0	N 54	N 54
11	α Cyg	N 67;0	N 60	N 60

Number	Modern Identification	Kharaqī	Ptolemy	Lat. Şūfī
13	α CrB	N 45;30	N 44;30	N 44;30
26	β Gem	N 7;15	N 6;15	N 6;15
40	α Cet	S 17;20	S 12;20	S 12;20
51	γ Crv (on the right wing)	--	S 14;50	S 14;50
	δ Crv (on the left wing)	S 12;30	S 12;30	S 12;30
53	β Cen	S 42;20	S 45;20	S 45;20
59	ϵ Boo	N 40;15	N 40;20	N 40;15
61	β Aur	N 22;0	N 20	N 20
64	ζ Dra	N 87;7	N 84;50	N 84;50
69	δ Per	N 20;20	N 27;20	N 27;20

4. On the Precession

The date of the redaction of astronomical work, including data on fixed stars, could be determined by subtracting its values from Ptolemy's or al-Şūfī's values and dividing the result by the rate of precession because many of these works explicitly give *Almagest* or *Şuwar* as their principal source. However, the rate of precession is not unique. Moreover, the concept of year in this definition is not clear, and in a few cases, a lunar year (Hijrī), instead of a standard solar year (Persian or Egyptian), was the base of the recalculation of the star coordinates.

The rate of precession is not unique because lack of a consensus on its value:

- Ptolemy's value is one degree in 100 years which is as same as Hipparchus' value, -alin the Islamic period Farghānī and Ibn ¹ Haytham have the same value;²
- Al-Şūfī's value is one degree in 66 years,³ Kūshyār stated that the rate of the precession is 54 seconds per year and a complete

1. Ptolemy (1984, p. 328); Neugebauer (1975, p. 293).

2. Alfarganvs, (1669, p. 74); Langermann (1990, p. 61 Arabic text).

3. al-Şūfī, (1986, p. 31).

23/ Kharaqī's Star Catalogue...

rotation takes 24,000 years,¹ the same value given by al-Şūfī. Most the Islamic astronomers accept this value for the rate of precession;

- Some other astronomers determine a more accurate value for precession such as one degree in 70 years.² The modern value for the rate of precession is one degree in 71.6 years,³ so one degree in 70 years is the most precise value given in the Islamic period.

Kharaqī, as he says, reproduces the star catalogue according to the rule of one additional degree for every 66 years. Fortunately, in this case, Kharaqī explicitly says that the sum of additional values is two degrees and fifteen minutes which should be added to Şūfī's values.⁴ The additional value 2;15 is equivalent to 148 years; hence, the table reproduction year should be 1424.

Supposing that Kharaqī's values are for the year 1444 of the Alexandrian era/526-527 A.H, as it is stated in most of *Munataha*'s manuscripts, we can check his values by Şūfī's and the interval period. Şūfī set his catalogue for the year 1276 of the Alexandrian era/353-354 A.H,⁵ that is, 168 years before Kharaqī. Hence the added value, regarding one degree for 66 years, should be almost two degrees and thirty-three minutes. In this step, the star table's data indicates if the table production year is 1444 and the additional value should be 2;33; or the additional value is 2;15, and the production year should be 1424.

It could be verified by a star table written around the same time, 'Abd al-Raḥmān al-Khāzinī compiled his *Zīj* titled *al-Zīj al-Mu'tabar al-Sanjari*, in 509 A.H., which is the year 1427 of the Alexandrian

1. Kūshyār Jilī, (fol. 105v).

2. Caussin de Perceval (1803-1804, p.171); F.J. Ragep (1993, pp. 124-125 Arabic Text); Naşīr al-Dīn al-Ṭūsī (*Īlkhānī Zīj*, p. 195); also see. Kennedy (1956, pp. 153,160, 163,165); Mozaffari (2008, p. 29).

3. Mozaffari, (2008, p. 29).

4. 'abd al-Jabbār al-Kharaqī (2020, p. 99. Paragraph [197]).

5. al-Şūfī, (1986, p. 31).

era.¹ The *Zīj* includes a fixed stars table containing 43 stars. Khāzinī noted that his table is a reproduction of the catalogue in *Almagest* by adding 15 degrees to star longitudes.² A study of this table shows that its values are three minutes more than Kharaqī's. (See Table 6) There are some discrepancies between the two catalogs which for the most part could be referred to as scribal errors; these rows are shown in Table 6 in different colors. Considering the additional value of al-Ṣūfī to *Almagest*, which is 12;42,³ Kharaqī's additional value to *Almagest* is 14;57. The difference of three minutes illustrates that Khāzinī's table is produced three years after Kharaqī's table.

Table (6): a comparison between Kharaqī's star table and Khāzinī's in his *al-Mu'tabar*

Number in Kharaqī's catalogue	Modern Identification	Star names	Longitude in <i>al-Mu'tabar</i>	Longitude in <i>Montaha</i>
19	α And	ra's al-mar'at al-musalsalat (Kharaqī: surrat al-faras)	Ari 2;50	Ari 2;27
46	θ Eri	ākhir al-nahr	Ari 15;10	Ari 15;7
23	β And	baṭn al-ḥūt	Ari 18;50	Ari 18;47
8	β Cas	Al-kaff al-khaḍīb	Ari 22;50	Ari 22;47
76	α Ari	al-nāṭiḥ	Ari 25;40	Ari 26;37
74 & 82	α Tri	ra's al-muthallath	Ari 26;0	Ari 25;57
80	γ And	rijl al-musalsalat	Tau 1;50	Tau 1;47
16	β Per	ra's al-ghūl	Tau 15;40	Tau 15;37
15	α Per	janb Barshāwūsh	Tau 19;50	Tau 19;47

1. Khāzinī's table is a reproduction of *Almagest*, as he explicitly indicated, but for the rate of the precession, he followed al-Ṣūfī, not Ptolemy. The period between Khāzinī, who flourished in the late 11th century, and Ptolemy (2nd century A.D.) is less than ten centuries; since he added 15 degrees to *Almagest* values, his rate of precession could not be the same as Ptolemy's because, in this case, the period between them would be fifteen centuries.

2. Khāzinī, (fols. 191v-192r).

3. al-Ṣūfī, (1986, p. 32).

25/ Kharāqī's Star Catalogue...

Number in Kharāqī's catalogue	Modern Identification	Star names	Longitude in <i>al-Mu'tabar</i>	Longitude in <i>Montaha</i>
		(Kharāqī: mirfaq al-thurayyā)		
24	α Tau	al-dabarān	Tau 27;40	Tau 27;37
43	β Ori	rijl al-jawzā (Kharāqī: rijl al-jawzā' al-yusrā)	Gem 4;50	Gem 4;47
7	α Aur	ayyūq	Gem 10;0	Gem 9;57
41	α Ori	yad al-jawzā (Kharāqī: yad al-jawzā' al-yumnā)	Gem 17;0	Gem 16;57
49	α Car	suhayl	Cnc 2;10	Cnc 2;7
47	α CMa	al-shi'rā al-Yamāniyyat	Cnc 2;40	Cnc 2;37
--	--	janb al-taw'am al-tālī	Cnc 6;40	--
25	α Gem	ra's al-taw'am (al-muqaddam)	Cnc 8;20	Cnc 8;17
48	α CMi	al-shi'rā al-shāmiyyat	Cnc 14;10	Cnc 14;7
50	α Hya	al-fard	Leo 15;0	Leo 14;57
28	α Leo	qalb al-asad	Leo 17;30	Leo 17;27
77	δ Leo	zahr al-asad	Leo 29;10	Leo 29;29
29	β Leo	al-ṣarfāt	Vir 9;30	Vir 9;27
51	γ Crv	janāḥ al-ghurāb (Kharāqī: janāḥ al-ghurāb al-'ayman)	Vir 28;30	Lib 1;37
30	α Vir	simāk al-a'zal	Lib 11;40	Lib 11;37
14	α Boo	simāk al-rāmiḥ	Lib 12;0	Lib 11;57
52	α Cen	rijl qantūris (Kharāqī: rijl qantūris al-	Lib 23;20	Lib 23;17

Number in Kharaqī's catalogue	Modern Identification	Star names	Longitude in <i>al-Mu'tabar</i>	Longitude in <i>Montaha</i>
		yumnā)		
13	α CrB	al-munīr min al-fakkat	Lib 29;40	Lib 29;37
68	α Ser	'unuq al-ḥayyat	Sco 9;20	Sco 9;17
33	α Sco	qalb al-'aqrab	Sco 27;40	Sco 27;37
66	α Her	ra's al-jāthī (Kharaqī: al-jāthī)	Sgr 2;40	Sgr 2;37
18	α Oph	ra's al-ḥawwā	Sgr 9;50	Sgr 9;57
9	α Lyr	nasr al-wāqī'	Cap 2;20	Cap 2;17
10	α Aql	nasr al-tā'ir	Cap 18;50	Cap 18;47
12	β Cyg	minqār al-dajājat	Cap 19;30	Cap 17;7
54	ε Del	dhanab al-Dulḥīn (Kharaqī: 'amūd al-ṣalīb)	Aqr 2;40	Aqr 2;37
73	δ Cap	dhanab al-Jady	Aqr 11;20	Aqr 11;17
56	ε Peg	ḥajfalat al-faras	Aqr 20;20	Aqr 20;27
39	α PsA	fam al-ḥūt al-junūbī	Aqr 22;0	Aqr 21;57
11	α Cyg	dhanab al-dajājat (Kharaqī: al-ridf)	Aqr 24;10	Aqr 22;7
22	α Peg	matn al-faras	Psc 11;40	Psc 11;37
21	β Peg	mankib al-faras	Psc 17;10	Psc 17;7
58	ι Cet	dhanab qayṭis	Psc 19;20	Psc 19;17
20	γ Peg	janāh al-faras	Psc 27;10	Psc 27;7

In conclusion, the decisive date of Kharaqī's star catalogue is 1424. Close scrutiny of *Muntaha*'s five extant manuscripts shows that three

27/ Kharaqī's Star Catalogue...

manuscripts have 1444,¹ a manuscript has 1424 in the body of the text² and a manuscript has 1424 as a marginal note.³ In *Muntaha*, there are at least two indications supporting that the book was written in 1444: 1- Kharaqī asserts that the degree of the apogee of the sun, the location of the north pole and the degrees of the apogees of the planets are for the year 526 A.H./1444 Alexandrian; 2- In the section on calendar conversions, most of the examples are for the year 526 A.H..⁴ Hence, it is plausible to suggest the book was written in 1444, but that the star table is copied from a source relating to 1424 without further corrections for 1444.

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1. 'Abd al-Jabbār al-Kharaqī, *Muntaha al-'idrāk fī taqāsīm al-'aflāk*, MS. Bibliotheque nationale de France, Paris, no. arabe 2499, fol. 45v; MS. Majlis Shawra library, Tehran, no. 6413, fol. 60v; MS. Biblioteca Medicea Laurenziana, Florence, no. Orientali 110, fol. 35v.
 2. 'abd al-Jabbār al-Kharaqī, *Muntaha al-Idrāk fī Taqāsīm al-Aflāk*, MS. Staatbibliothek zu Berlin, no. 33 Landberg, fol. 30r.
 3. 'abd al-Jabbār al-Kharaqī, *Muntaha al-Idrāk fī Taqāsīm al-Aflāk*, MS. Taymūr, Dār al-Kutub, Cairo, no. Riyādiyyāt 111, fol. 49r.
 4. 'abd al-Jabbār al-Kharaqī (2020, pp. 42-43 introduction).

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29/ Kharaqī's Star Catalogue...

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31/ Kharaqī's Star Catalogue...

Appendix

Kharaqī's catalogue

MS. Staatbibliothek zu Berlin, no. 33 Landberg, (B), fols. 30r-31r

MS. Bibliothéque nationale de France, Paris, no. arabe 2499, (P), fols. 46r-47v

MS. Majlis Shawra library, Tehran, no. 6413, (M), fols. 61r-62v

MS. Taymūr, Dār al-Kutub, Cairo, no. Riyāḍiyyāt 111, (Q), fols. 49v-51r

MS. Biblioteca Medicea Laurenziana, Florence, no. Orientali 110, (F), fols. 36r-37v

مواضعها في الصور	عظمه ا	جهت ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			ف: ٣	ن: ٣	ف: ٣	ن: ٣	ن: ٣	
من كواكب الدب الأصغر ^٥	ج ^٤	نور	٥	سز ^٣	ز ^٢	يه ^١	ب	الجُدِّي وهو ذَنب الدب الأصغر
	ب		ن ^٩	عب ^٨	ز ^٧	ب	د	أنور ^٦ الفرقدين
	ج ^{١٣}		ن	عد ^{١٢}	ز ^{١١}	يا	د ^{١٠}	أخفى الفرقدين
ذَنب الدب الأكبر	ب		ل ^{١٨}	نجز ^{١٧}	ز ^{١٦}	كز ^{١٥}	د ^{١٤}	الجَوْن
	ب ^{٢١}		م	نه	نز ^{٢٠}	ب ^{١٩}	ه	العِنَاق
	ب		٥	نز ^{٢٤}	مو ^{٢٣}	يز ^{٢٢}	ه	القائد
منكب ذي العنان	ا		ل	كب	نز ^{٢٧}	ط ^{٢٦}	ب	العَيَوق ^{٢٥}

1. F: د

2. P: يز

3. P: يو; F: سو

4. F: د

5. F: من كواكب الدب الأكبر

6. F: نور

7. P: يز

8. M, Q, F: كب

9. M, Q, F: ز

10. F: ز

11. P: يز

12. M, Q, F: كد

13. P: د

14. P, F: ز

15. F: كد

16. P: يز

17. D: ي

18. F: ز

19. P: ج

20. P: نو; F: ز

21. P: ا

22. B, P, F: يد

23. P: نو; Q, F: يو

24. P: ند

25. F: add. كف الحضيبي

26. P: ي

27. P: نو; M: يز; F: يو

33/ Kharaqī's Star Catalogue...

مواضعها في الصور	عظمه ا	جهت ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			ق ^١ د ^٢	ن ^٣	ق ^٤ د ^٥	ن ^٦	ن ^٧	
من كواكب ذات الكرسي	ج ^٤	ر ^٨	م ^٣	نا	مز ^٢	كب	o	الكفُّ الخضيب ^١
من الصنج الرومي ^٧	ا		o	سب	يز ^٦	ب	ط	النسر الواقع ^٥
من كواكب العقاب	ب		ى	كط	مز ^٩	يح	ط	النسر الطائر ^٨
وهو ذنّب الدجاجة	ب		o	سز ^{١٣}	ز ^{١٢}	كب ^{١١}	ى	الردف ^{١٠}
	ج		ك	مط ^{١٦}	ز ^{١٥}	يز	ط	منقار الدجاجة ^{١٤}
	ب		ل	مه	لز ^{١٨}	كط	و	النير من الفكة ^{١٧}

1. F: add. النسر الواقع

2. P, F: نر

3. P: و

4. P, Q, F: د

5. F: add. النسر الطائر

6. P: نس; F: ن

7. F: الرامي

8. F: add. الردف

9. P, Q, F: يز

10. F: add. منقار الدجاجة

11. M: كز; B: كد

12. P, Q, F: مز

13. P, Q, F: ك

14. F: add. النير من الفكة

15. F: د

16. Q, F: يط

17. F: السماك الرامح

18. P, Q, F: ز

مواضعها في الصور	عظمه ا	جهت ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			ف: ق	ن	ف: ق	ن	ن	
من كواكب العوا ^٣ خارج عن ^٤ الصورة	ا	البرق	ل	لا	نز ^٢	يا	و	السِّماك الرامح ^١
وهو جنب برشاوش	ب		ل	ل	مز ^٦	يط	ا	مرفق الثريا ^٥
	ب		ل	كج	لز ^٨	يه	ا	رأس الغول ^٧
مِعَصَم الثريا	سج		ل	م ^{١١}	لز	يا	ا	اليد ^٩ اليمنى من برشاوش وهو السُّوَيْعَد ^{١٠}
	ج ^{١٥}		ل	لو	نز ^{١٣}	ط	ح	رأس الحوا و يقال له ^{١٢} الراعي

1. F: add. مرفق الثريا

2. P, F: يو

3. P: من كواكب الغول

4. F: om. عن

5. F: add. رأس الغول

6. P, F: يز

7. F: add. اليد اليمنى من

برشاوش

8. P, Q, F: مز

9. M: اليه

10. F: add. رأس الحوا وهو

هو السُّوَيْعَد. F: om. الراعي

11. F: مز

12. F: وهو

13. P, F: لز

14. F: كا

15. P, F: د

35/ Kharaqī's Star Catalogue...

مواضعها في الصور	عظمه ١	جهات ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			دقائق دقيقة	دقائق دقيقة	دقائق دقيقة	دقائق دقيقة	دقائق دقيقة	
	ب	شمس البرق	٥	كو	كزا ^١	ب	٥	سُرَّة الفرس
	ب ^٢		ل	يب	ز	كز	يا	جَنَاح الفرس
	ب		٥	لا ^٣	ز	يز	يا	مَنكَب الفرس
	ب		م ^٥	يط	لز	يا	يا	متن ^٤ الفرس
وهو جنب المسلسلة	ب	شمس النور	ك	كو ^٦	مز ^٦	يح	٥	بطن الحوت
وهو عين الثور ^{١١}	ا		١٠	ه	لز	كزا ^٩	ا	الدبران ^٨
	ب ^{١٣}	شمس البرق	م	ط	يز	ح	ج ^{١٢}	رأس التوأم المقدم
	ب		يه	ز	لز	يا	ج ^{١٤}	رأس التوأم المؤخر

1. P, F: يز

2. M, Q: ا

3. M: ٥

4. F: بطن

5. F: و

6. P, F: ك

7. Q: يو

8. F: البراق

9. Q: لز

10. P, F: ك

11. P: om. وهو عين النور

12. F: د

13. P: ا

14. F: د

مواضعها في الصور	عظمه ١	جهت ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			دقايق	دقائق	دقائق	دقائق	دقائق	
من كواكب السرطان	١	شمال	م	٥	يز	كه ^١	ج	المعلف
وهو الذي يقال له الملكي ^٢	١		ي	٥	كز	يز	د	قلب الأسد الفلكي ^٢
وهو على ذنب الأسد	١	جنوبي	ن	يا	كزه	ط	هـ	الصرفة
وهو على راحة العذراء	١		٥	ب	لز	يا	و	السماك الأعزل
من كواكب الميزان	ج		م	٥	نز ^٧	ب	ز ^٦	الأنور من الزبانا الجنوبي
من كواكب الميزان	ب	شمال	ن ^٩	ح	ن ^٨	كج	ز	الأنور من الزبانا الشمالي

1. P, F: يب; Q: كب

2. B, M, Q, F: الملكي

3. F: د

4. F: om. وهو الذي يقال له

الملك

5. F: كو

6. F: ب

7. P, Q, F: يز

8. M, F: ز

9. P, F: له

37/ Kharaqī's Star Catalogue...

مواضعها في الصور	عظمه ا	جهت ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			دقائق د	دقائق د	دقائق د	دقائق د	دقائق د	
	ب	جنوبي	٥	د ^٣	لز ^٢	كز	ز ^١	قلب العقرب
	ج ^٤	شمالي	ك	ا	يز	كا	زه	الشمالي من الثلاثة التي في جبهة العقرب ^٤
	ج	جنوبي ^٥	م	ا	لز	ك	ز ^٧	الوسط منها
	ج ^٦	جنوبي	٥	ه	لز	ك	ز	الجنوبي منها
	سحابي		يه	يج	ز	يو ^{١٢}	ح	التالي ^{١٠} لجبهة ^{١١} العقرب
	سحابي	شمالي	مه	٥	ز	٥	ط	عين الرامي

1. M, Q: و

2. P: نر; F: يز

3. P, F: ج

4. B: ... من الستة التي في ناحية

الشمالي من السلة P; العقرب

الشمالي Q; إلى ناحية العقرب

F: من الثلاثة في ناحية العقرب

الشمالي من السلسلة

5. P, M, Q: و

6. P: د

7. P, M, Q: و

8. F: شمالي

9. P: يج

10. F: انالي

11. P: لجملة

12. M: يز

مواضعها في الصور	عظمه ا	جهت ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			ف١ ق١	ن١	ف٢ ق٢	ن٢	ن٣	
	ا	↑ ن١ ↓	٥	كج	نز٣	كا	ى	فم الحوت الجنوبي وهو الضفدع الأول ^١
وهو الثاني من صورة قيطس	ج		ك	يز	لز٤	ب	ا	الكف الجذما
	ا		٥	يز	نز٧	يو٦	ب	يد الجوزاء اليمنى
من كواكب الجبار	ب		ل	يز	نز٩	ح	ب	منكب الجوزاء اليسرى ويقال له المرزم ^٨
	ا		ل١٢	لا	مز١١	د١٥	ب	رجل الجوزاء اليسرى

1. B, P: om. فم

2. F: om. وهو الضفدع الأول

3. P: ز

4. B, Q: كز; P: نز

5. F: om. صورة

6. F: يز

7. P: كز; F: يز

8. F: منكب الجوزاء وهو المرزم

9. P, F: يو; Q: يز

10. P, F: ج

11. P: ن; F: ن

12. P, F: د

39/ Kharaqī's Star Catalogue...

مواضعها في الصور	عظمه ا	جهت ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			ن ^٣	ن ^٢	ن ^٤	ن ^٣	ن ^٢	
	ب	ب ر أ	ن ^٣	كد ^٢	يو	يب	ب	الوسط من المنطقة
	ج		ل	لج ^٤	ز	يه	ب	الرجل اليمنى من الجوزاء
	ا		ل	نجم ^٤	ز	يه	٥	آخر الزهرة
من كواكب الكلب الأكبر ^{١١}	ا		ي ^{١٠}	لط ^٩	لز	ب	ج	الشعري اليمانية وهي ^٧ العبور ^٨
من كواكب الكلب الأصغر	ا		ي ^{١٤}	يو	ز	يد	ج	الشعري الشامية ^{١٢} وهي الغميصاء ^{١٣}
من كواكب السفينة	ا		٥	عه ^{١٦}	ز	ب	ج ^{١٥}	سهيل

1. F: وسط المنطة

2. M: كز

3. B: نر; P, Q, F: ند

4. F: يج

5. P: آخر الزهرة

6. P, F: ط

7. M, P: هو

8. F: om. وهي العبور

9. M: يظ

10. P, F: د

11. M, F: om. الأكبر

12. P: اليمانية

13. F: om. وهي الغميصاء

14. P, F: د

15. P: د

16. M, P, F: كه

مواضعها في الصور	عظمه ا	جهت ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			قفا قفا	ن ن	قفا قفا	ن ن	ن ن	
من كواكب الشجاع	ب	١٠ ↑ ريبي	ل	ك ^٥	نز ^٤	يد ^٣	د ^٢	الفردا
	ج ^٨		ل	يب	لز ^٧	ا	و	جناح الغراب الأيمن ^٦
	ا		ى	ما	يز	كج ^٩	و	رجل قنطورس اليمنى
	ب		ك	مب	مز	يا	ز ^{١٠}	رجله اليسرى
وهو ذئب الدلفين	ج		ى ^{١٣}	كط	لز ^{١٢}	ب	ى ^{١١}	عمود الصليب
من كواكب برشاوش	د	١١ ↑ برشاوش	ن ^{١٦}	كز ^{١٥}	يز	ك	ا	قابض الثريا ^{١٤}
من كواكب الفرس الأعظم	ج ^{٢٠}		ل	كب ^{١٩}	كز ^{١٨}	ك	ى ^{١٧}	حجفلة الفرس

1. P, Q, F: القرد

2. B: ج

3. M: يه

4. F: يز

5. M, Q: كه

6. F: اليمين

7. F: لو

8. P, F: د

9. Q: ل

10. P, F: و

11. P, Q, F: د

12. P: لب; Q: يز

13. P, F: د

14. M, F: مابض الثريا

15. F: كو

16. M, P, Q, F: ز

17. P, F: د

18. Q: لز

19. P, Q: كز; F: كو

20. B: د

41/ Kharaqī's Star Catalogue...

مواضعها في الصور	عظمه ا	جهت ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			دقائق	دقائق	دقائق	دقائق	دقائق	
من كواكب الفرس الأعظم	ج		0	يح	مز	ج	يا	الأنور من سعد البهائم
	ج	جنوبي	م	ط	يز	يط	يا	ذَنب قَيْطِس
من كواكب العوا	ج	شمالي	يه	م ⁴	نز ³	يز ²	و	دابة السماك وهو أحد كوكبي الرمح ¹
	ج		0	كح ⁵	يز	و	و	الثاني من كوكبي الرمح
من كواكب ذى العنان ⁷	ب		0	كب	مز ⁶	يز	ب	رجل العيوق
	ج	جنوبي	0	يح ⁹	نز ⁸	ا	ط	ركبة الرامي

1. Q: راية السماك وهو أحد

السماك من F; كوكبي الرمح

كوكبي الرمح

2. P, Q: يد; B, F: نند

3. F: يز

4. P, F: هـ

5. P, F: يا

6. P, F: يز

7. F: om. من كواكب ذى

العنان

8. Q, F: يز

9. M, Q, F: ح

مواضعها في الصور	عظمه ا	جهت ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			قفا قفا	ن	قفا قفا	ن	ن	
من كواكب التين	ج ^٣	نجم	ع ^٢	لز	كز	ه	الذبيح ^١ وهو ذكر الضباع	
	ج ^٧		ز ^٦	فز ^٥	يز	كج	ه	أحد الذئبين وهما العوهقان ^٤ والجروان ^٤
من كواكب تين	ج		ع ^{١٥}	نز ^٩	كد	ه ^٨	الثاني منهما	
وهو الذي ^{١٣} على رأسه	ج ^{١٢}		ل	لز ^{١١}	ب	ح	الجاثي	
من كواكب قيطس	ج		نجم	ك	ك	لز	ك	يا

1. P: الذكر

2. Q: بيح

3. Q: distorted; This line is not readable in B

4. P: والجوان; Q: om.

أحد التينين وهما F: والجروان

5. P, F: مه

6. B: ن

7. B, F: د

8. P, F: ح

9. F: يز

10. P, F: كج

11. P, Q, F: لو

12. F: د

13. F: التي

43/ Kharaqī's Star Catalogue...

مواضعها في الصور	عظمه ا	جهت ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			دقايق	دقائق	دقايق	دقائق	دقائق	
	ج	شمال	ك	كه	يز ^٢	ط	وا ^١	عُنُق الحية
من كواكب برشاوش	ج ^٤		ك	ك	لز	كب	ا	أحد كوكبي عضد الثريا ^٣
من كواكب برشاوش	د		ن ^٥	كا	مز	كا	ا	الثاني منهما
	ج		٥	يب	ز	يط	ا	عائق الثريا أحد كوكبيه ^٦
	ج		٥	يا	يز	كا	ا	الثاني منهما
	ج	جنوبي	٥	ب	يز	يا ^٧	ى	ذَنَب الجدي
	ج ^{١٢}	شمالي	ل	يو ^{١١}	نز ^{١٠}	كو ^٩	٥	رأس المثلث ^٨

1. B, M, F: ز

2. M, P, Q, F: يو

3. F: عضد السها

4. F: د

5. P, F: ز

6. Q: أحد كوكبه; F: om.

أحد كوكبيه

7. P, F: كو

8. B, P, Q, F: الملتهب

9. P, F: ى

10. P, F: يز

11. F: نو

12. B, Q, P, F: ب

مواضعها في الصور	عظمه ١	جهت ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			ف١ ق١	ن١	ف٢ ق٢	ن٢	ن٣	
مشارك بين صورة ذي العنان وبين قرن الثور	ب ^٤	الذئب	٥	هـ	لز	ي ^٣	ب	قرن الثور وهو كعب ^١ ذي العنان ^٢
من كواكب الحمل، خارج عن الصورة	ج ^٧		٥	ي ^٤	لز	كو ^٥	٥	الناطح
	ب ^{١٠}		م	يج	كط	كط ^٩	د ^٨	ظهر الأسد
	د ^{١٢}	الذئب	٥	كج	لز	ب ^{١١}	ط	عُرقوب الرامي

1. F: كف

2. B, P, Q: كف العنان

3. P, F: مو

4. P, F: ج

5. P, F: كط

6. F: ك

7. P, F: ب

8. P, Q: ز

9. P, F: ب

10. P, F: ج

11. P, F: يز

12. P, F: ب

45/ Kharaqī's Star Catalogue...

مواضعها في الصور	عظمه ا	جهت ها	عروضها		أطوالها			أسماء الكواكب الثابتة
			ف ^١	ن ^٢	ف ^٣	ن ^٤	ن ^٥	
	ب ^٤	ن ^٦	ل	ح	ز ^٣	يز ^٢	دا	منكب الأسد
	ج ^٨		و	كح	مز ^٧	ا ^٦	ا	رجل المسلسلة وهو العناق ^٥
خارج عن الصورة الدب الأكبر	ج ^{١٢}		مه	لط ^{١١}	مز	يب ^{١٠}	هـ	كبد الأسد بين القائد والفقرة الأولى ^٩
من كواكب المثلث	ج		ل	يو	نز ^{١٥}	كه ^{١٤}	و	أحد كوكبي الأنيسين ^{١٣}
يطلعان قبل الشرطين	ج ^{١٩}		م ^{١٨}	ك ^{١٧}	نز ^{١٦}	و	ا	الثاني منهما
على منكب الملتهب	ج ^{٢١}		و	سط ^{٢٠}	لز	ا	و	الأبيض

1. P: ز

2. P, F: ا

3. F: م

4. P, F: ج

5. F: om. وهو العناق

6. B, F: ب, P, Q: يب

7. P, F: م

8. P, F: ب

9. M: القفرة; B: القفرة; F:

om. كبد الأسد بين

10. P, Q: كه; F: كط

11. M: لو; P: يبط

12. P: ب

13. F: الأسعدين

14. P, Q, F: و

15. P, F: يز

16. P, F: يز

17. B: كب; P, F: سط

18. P, F: و

19. F: د

20. P, Q, F: د

21. F: د