



THE STUDY OF ARABIC CONSTELLATION FROM THE BOOK SUWAR AL-KAWAKIB AL-THABITA USING STELLARIUM SOFTWARE

Hariyadi Putraga^{1*}, Arwin Juli Rakhmadi Butar-Butar¹, Muhammad Hidayat¹, Muhammad Dimas Firdaus¹

¹Observatory of Falak, Universitas Muhammadiyah Sumatera Utara
Denai Street No. 217, Medan, Indonesia, 20216

*Email: hariyadiputraga@umsu.ac.id

Abstract: The constellations originating from Arab civilization were still very little known and studied. Al-Šūfi's book, *al-Kawākib al-Thābitah*, contains the record of coordinates, approximate magnitudes, and star details with graphs. This study examines the difference of stars in the sample constellation, compares the visual appearance of the illustrations on the Stellarium software, and studies the differences between the western constellations and the Arabic constellations. The result shows some differences between the constellations of the *almagest* and *al-Kawākib al-Thābitah* in the number of stars in the sample constellations, differences in illustrations from the orientalized figures, and the star magnitude in al-Šūfi's work that similar to Ptolemy's works. Al-Sufi identified a total of 134 additional stars, 65 stars located in the Northern constellations, 41 stars in the Zodiac constellation, and 28 stars in the Southern constellations. His observations showed that the magnitude values of 520 stars out of a total of 1022 stars were identical between al-Sufi and Ptolemy. Stellarium provides an excellent visual presentation of the Arabic constellations according to Al-Sufi's book that shows position, illustration, and mapping in the night sky.

Keywords: Al-Sufi, Arabic civilization, constellation, software, stellarium

Abstrak: Rasi bintang yang berasal dari peradaban Arab masih sangat sedikit diketahui dan dipelajari. Buku Al-Šūfi, *al-Kawākib al-Thābitah* berisi catatan koordinat, perkiraan besaran, dan detail bintang dengan grafik. Penelitian ini mengkaji perbedaan bintang pada rasi sampel, membandingkan tampilan visual ilustrasi pada software Stellarium, dan mempelajari perbedaan antara rasi Barat dan rasi Arab. Hasil penelitian menunjukkan beberapa perbedaan konstelasi antara *almagest* dan *al-Kawākib al-Thābitah* dalam hal jumlah bintang pada rasi bintang, perbedaan ilustrasi dari figur yang diorientasikan, dan magnitudo bintang pada karya al-Šūfi yang mirip dengan karya Ptolemeus. Al-Sufi mengidentifikasi total 134 bintang tambahan, 65 bintang terletak di konstelasi Utara, 41 bintang di konstelasi Zodiak, dan 28 bintang di konstelasi Selatan. Pengamatannya menunjukkan bahwa nilai magnitudo 520 bintang dari total 1022 bintang adalah identik antara al-Sufi dan Ptolemy. Stellarium memberikan presentasi visual yang sangat baik dari rasi bintang Arab menurut buku Al-Sufi yang menunjukkan posisi, ilustrasi, dan pemetaan di langit malam.

Kata Kunci: Al-Sufi, konstelasi, peradaban Arab, perangkat lunak, Stellarium

Introduction

The knowledge of astronomy that has been achieved in this age, was the result of the great efforts of astronomers, philosophers, and thinkers of the past in studying and developing their thought and views towards the sky they observe. Astronomy is also like a branch of a tree that develops with the spread of the roots of knowledge and the development from time to time (Hafez, 2010). Artisan contributes their work to be able to spread knowledge and knowledge and generate interest in astronomy.

Astronomy developed from earlier civilizations' problems like finding the right time to grow crops, and harvest crops, also the commemoration of religious days. Astronomy even used to find turning points and latitudes for long voyages on sea. People were very curious to find a connection between day and night, the Sun and the Moon, as well as the stars that subsequently sent them to the visibility of celestial bodies (Putraga, 2016).

This interest in observing the stars led an astronomer from Greece named Ptolemy to write a stars catalog including what we know now as the 48 classic constellations in 150 AD. The *almagest* lists 1,025 fixed stars with their ecliptic coordinates and magnitudes, which are further grouped into 48 constellations. This work is the most famous medieval star catalog in the Arab world (before the 12th century) (Sela, 2016).

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According to Paul Kunitzsch, the local tradition from Islamic lands in the Arabian Peninsula and the Middle East has their names for various bright stars such as Aldebaran, and they usually consider single stars to represent animals or humans. For example, the stars we know as Alpha and Beta Ophiuchi are considered to be shepherds and their dogs. Other star names used by al-Sufi and his associates are direct translations of Ptolemy's description. For example, the star name Fomalhaut comes from Arabic meaning "southern fish mouth" in the almagest book (Putraga, 2020).

The great Arabic astronomer, Al-Sufi, made an updated version of the Almagest, which contains many Arabic star names. Al-Ṣūfī's work named 'Book of the Fixed Stars', which dates back to around 964 AD, is one of the most important medieval Arabic astronomy treasure. This masterpiece contains stars that list the stars coordinates and approximate magnitudes, as well as star details with their graphs. Other topics include descriptions of nebulae and astronomy of the Arab people. There is currently no English translation of this important treatise (Hafez, 2010).

The original Arabic book was al-Ṣūfī is 'Ṣuwar al-Kawākib al-Thamāniyah wa-al-Ārba'een' which is simply translated as '48 Constellations'. However, he was later known by other names, the most famous of which were: 'Kitab al-Kawākib al-Thābitah' or 'The Book of the Fixed Stars' and 'Kitāb al-Kawākib al-Thābitah Muṣawaran' or 'The Illustrated Book of the Fixed Stars'. Al-Sufi's original Arabic text contains 55 astronomical tables as well as star graphs of 48 constellations of stars. Al-Sufi commented in detail on each constellation on each part of that star chart (Al-Ajaji, 2021). This knowledge has brought stars – stars that have Arabic names to the western world from the middle ages, with the largest number of Arabic stars of the Sufi (964 AD) to the astronomical overview of Spanish King Alfonso X (Lebling, 2010).

To introduce astronomy for beginners, the thing that is most considered as obstacle is the availability of astronomical instruments and their practical in learning astronomy (Qorib et al., 2021). The content of the book is science that is written and disseminated to the world in the form of literacy. With current technology, the contents of the book can also be obtained in the form of a digital electric book. The content of the book also can convert into a digital visual display which certainly be a new foothold in the world of astronomy that helps researchers to understand more about the thoughts and submissions of al-sufi in making of the book.

A. Constellation identification on Al-Sufi's work

Al-Sufi identified 48 constellations taken from Ptolemy's Almagest. He also counted the number of stars that previous astronomers presented in each constellation that shows 917 stars belonging to the main constellation and 118 stars outside the constellation. He mentions that others also miscalculated the number of stars in the sky which is only 1025 stars and proof this is wrong because there are many stars with magnitudes 5 and 6 was seen. Each star had different brightness which was influenced by the magnitude of the star and observer is located the sky state (Amri & Hadi, 2020).

In his work, Al-Sufi made improvements and comparisons to "mubadirah I'tidalain (axial precision), he was guided by the star magnitude based on observations and the same time comparing with the magnitude of the planets based on the standards of Ptolemy (Rakhmadi, 2019).

Al-Sufi then summarizes the total number of bright- observed stars is 1022, except for the three stars that are part of the Asterism 'al-Dafira'. He also explained how the tables were compiled and the methods for using dual constellation graphs and figures. The following is an explanation of the 48 Constellations and the number of stars re-identified by al-sufi, which are divided between the northern constellation, the zodiac constellation, and the southern constellation.

Table 1. List of northern sky constellations

No.	Constellation name	Number of stars inside	Number of stars outside	Arabic names based on al-Sufi
1	Ursa Minor	7	1	al-Dub al-Aḡghar
2	Ursa Major	27	8	al-Dub al-Akbar
3	Draco	31	-	al-Tinnīn
4	Cepheus	11	2	Qīqāwūs; al-Multaheb
5	Bootes	22	1	al-'Awwā; al-Sayyāḥ; al-Naqqār; Ḥāris al-Shamāl
6	Corona Borealis	8	-	al-Iklīl al-Shamālī; al-Fakka
7	Hercules	28	1	al-Jāthī 'ala Rukbateh; al-Rāqeṣ
8	Lyra	10	-	al-Silyāq; al-Wazza; al-Subeḥ; al-Ma'refa; al-Sulaḥfāt
9	Cygnus	17	2	al-Tā'er; al-Dajāja
10	Cassiopeia	13	-	Dhāt al-Kursīy
11	Perseus	26	3	Barshāuṣh; Ḥāmel Ra's al-Ghūl
12	Auriga	13	-	Mumsek al-'Inān; al-'Inān; Mumsek al-A'ina
13	Ophiuchus	24	5	al-Ḥawwā'
14	Serpens	18	-	al-Ḥayyā
15	Sagitta	5	-	al-Sahem
16	Aquila	9	6	al-'Uqāb; al-Nasr al-Tā'er
17	Delphinus	10	-	al-Dalḥīn
18	Equuleus	4	-	Qu ṭ'at al-Faras
19	Pegasus	20	-	al-Faras al-A'ẓ am
20	Andromeda	23	-	al-Mara' al-Musalsala
21	Triangulum	4	-	al-Muthallath
	Total	330	29	359

The number of stars in the northern sky constellation which makes up the main body of the northern constellation are 330 and the 29 stars outside the constellation that make up a total of 359 stars. However, in its introductory chapter, al-Ṣūfī mentions that the number of stars there is 331 which are the inner part of the northern constellation and 29 which are outside the constellation with a total of 360 Stars in the northern constellation. This is because Ptolemy grouped 14 stars into the constellation Auriga whereas al-Ṣūfī found only 13, while the latter star was not visible to him.

Table 2. List of constellations in the Zodiac

No.	Constellation Name	Number of Stars inside	Number of Stars outside	Arabic names based on al-Sufi
1	Aries	13	5	al-Ḥamal
2	Taurus	32	11	al-Thawr
3	Gemini	18	7	al-Tawāmān
4	Cancer	9	4	al-Saraṭān
5	Leo	27	8	al-Asad
6	Virgo	26	6	al-'Adhrā'; al-Sunbula
7	Libra	8	9	al-Zubānayn; al-Mīzān
8	Scorpio	21	3	al-'Aqrab
9	Sagittarius	31	-	al-Rāmī; al-Qaws
10	Capricorn	28	-	al-Jadī
11	Aquarius	42	3	Sākib al-Mā'; al-Dalw
12	Pisces	34	4	al-Samakātān; al-Ḥūt
	Total	289	60	349

The number of stars in the constellation Zodiac which makes up the main constellation body are 289 and 60 stars outside the constellation, for a total of 349 stars. However, in its introductory chapter al-Sufi mentions that the total number of stars is 289 which is part of the constellation Zodiac and 57 outside the constellation, totaling 346 except for the asterism called 'al-D afira' which is a group of 3 stars.

Table 3. List of Southern Sky constellations

No.	Constellation Name	Number of Stars inside	Number of Stars outside	Arabic names based on al-Sufi
1	Cetus	22	-	Qītus
2	Orion	38	-	al-Jabbār; al-Jauzā'
3	Eridanus	34	-	al-Nahr
4	Lepus	12	-	al-Arnab
5	Canis Major	18	11	al-Kalb al-Akbar
6	Canis Minor	2	-	al-Kalb al-Mutaqadem; al-Kalb al-Aṣghar
7	Argo Navis	45	-	al-Safīna
8	Hydra	25	2	al-Shujā'
9	Crater	7	-	al-Bāṭriya
10	Corvus	7	-	al-Ghurāb
11	Centaurus	36	-	Qanṭurūs
12	Lupus	18	-	al-Sab'
13	Fig	7	-	al-Jamra; al-Majmara
14	Corona	13	-	al-Iklīl al-Janūbī
15	Australis	11	-	al-Ḥūt al-Janūbī
	Total	295	13	308

The number of stars in the southern constellation which makes up the main body of the constellation are 295 and 13 stars are outside the constellation with total 308 stars. In introductory chapter, al-Sufi mentions that the total number of stars is 297 which are inner part of the southern constellation, and 19 outside the constellations that 316 stars in total. This is because Ptolemy assigned 37 stars to the constellation Centaurus and 19 stars to the constellation Lupus, whereas al-Sufi found one less star in each of the two constellations. Another difference is that Ptolemy added 6 stars to the last constellation Piscis Austrinus whereas al-Sufi did not include these in his catalog nor did he mention them in the comments on this constellation in his book.

B. Constellation illustration

Ptolemy's description of the constellation is based on the interior point of view; therefore Ptolemy described the figure of the constellation from the middle position that looking up to the sky. But when constellations projected on the celestial sphere then the outside observer must see the opposite of the constellation of figures looking down in the world. However, in all the Arab and Islamic worlds the constellations the images were drawn on the front display, therefore, the images are mirrored to illustrate them looking toward the observer. It is not known why the Arabs used such a system to draw constellations on the globe. Most likely they want to avoid depicting those figures where they are represented from behind.

Since al-Sufi's work is based on Ptolemy's *Almagest*, then most of the constellation illustrations resemble a classical style similar to the constellation Farnese globe. But some figures have undergone a process of 'orientalization' that may have begun before al-Sufi began writing his work. This process is the result of the misunderstanding some Greek mythological figures as well as the mistakes of the copyists in some versions of the *Almagest*. The Adaptation of iconography form alters the basic Greco-Roman aesthetic and the attributes given to each image, adapting them to the mirror 'Eastern' style in its illustrative depictions (Fernandez, 2019).

Another classical-style diversion of constellations also due to the *Anwā'* tradition the influence that al-Ṣūfī taken into liking. For example, as in the Andromeda constellation, Al-Ṣūfī made two illustrations for this constellation. The first one showed Andromeda with his arms outstretched. The second was the figure of Andromeda with fish covering her legs (Figure 1). All this iconography is not part of the original classical Greek tradition (Rice, 1959).



Figure 1. Illustration of the constellations of Andromeda on the book of Al Sufi: Orientalization (left) and the Influence of the Anwa Tradition' (right)

Along with the technology development, the knowledge written by previous scientists' quality increased. In al-sufi's book, the stars and constellations data can still only be read and understood by people who have advance astronomy knowledge but were difficult to understood by novices. So, to introduce and disseminate the old knowledge of this constellation, it could also be published digitally and even be incorporated into applications/software that gave better description to the star and the image of that constellation in the sky. It is also necessary to develop the way of presenting and conveying information. Stellarium, is a software that gives users freedom to create and have a virtual planetarium. This software will perform calculations of celestial bodies the position that visible to the observer at the location and time given in the input. This software also capable to describe constellations and simulate astronomical phenomena such as meteor showers and eclipses. Stellarium is evolving so fast that each version of it provides even more facilities and information. (Putraga & Setiawan 2018). Stellarium is an open source project so that anyone can contribute to the development, and in the latest version, it provides constellation data derived from Arab civilization based on the work of Abd-al Rahman al-Sufi from the book of suwar al-kawakib al-thabita.

Manuscript of The Book of the Fixed Stars was critically edited, and the text was produced. Bintang members of the 48 constellations are identified according to al-Sufi descriptions. Nama stars native to Arabia were collected and identified as mapped by Al-Sufi to Ptolemaic (Al-Ajaji, 2021). All previous steps were included in the digitally published book of the Fixed Star plus explanations and commentaries by Khalid Al-Ajaji. Furthermore, the resulting illustrations are contributed to Stellarium Software so that they can be used and studied as shown in Figure 2.

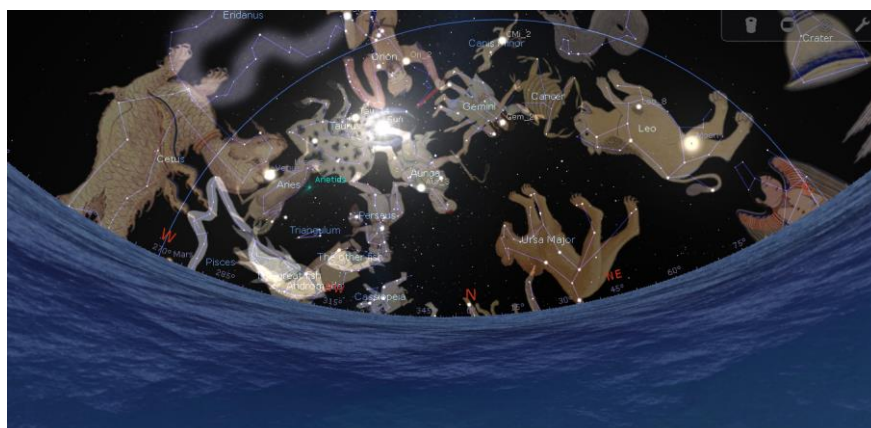


Figure 2. Stellarium gives the appearance of a constellation of stars and their illustrations based on the book by al-Sufi

To investigate the differences and developments of those constellations, writer took illustrations from the al-Sufi marsh144 manuscript and projections on modern graphs in the Stellarium app that shows the stars location in those constellations that had been created by the developers. As can be seen from the chart projections from Marsh144's manuscript for the constellation Orion (Figure 3), the chart was quite accurate and can be used as intended by al-Sufi in his Book in grouping the Bright Stars from his constellation.

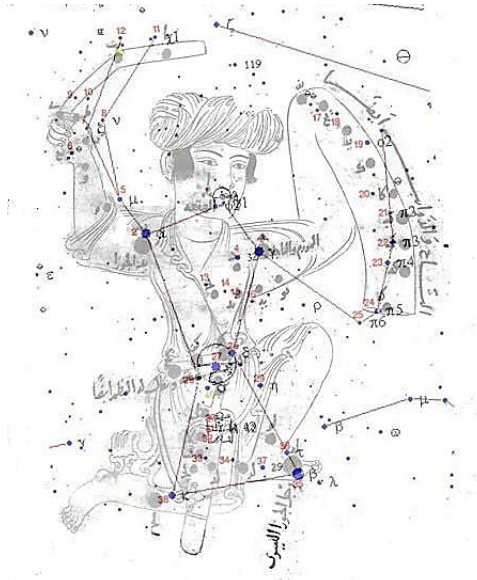


Figure 3. Projection of the constellation Orion from Marsh144 Manuscript

Stellarium illustration avoid plagiarism of the work, the contributor and developer made modifications to his illustrative imagery that prioritized the grouping of the main stars which further made quite representative illustrations in the depiction constellation illustrations based on al-Kawākib al-Thābitah by Al-Sufi and gave improvisation to colors to further give the impression of color images to the book.

The star in the constellation Orion in Arabic culture is called al-Jabbār because it stands on two legs with staff in its hand and a sword in the middle. Many of the stars that make up this constellation are as many as thirty-eight stars. In astronomy, the constellation Orion is formed by eight large stars namely Betelgeuse, Meissa, Bellatrix, mintakaAlnilam-Alnitak star array, Saiph, Rigel, also along with other small stars (Rakhmadi, 2018).

Some of the differences in the illustrative image of Orion between Ptolemy and Al-Sufi lies in the position of the star line and its image. In the Western constellation according to Ptolemy, the stars Saiph and Rigel are the position points of the Knees, while in Al-Sufi the description of the two stars is more likely to be in the position of the legs and the image of the person being the legs bent, not standing on both legs (Hafez, 2010).

A comparison of the illustrations of the Constellation Orion on Arabic culture from al-sufi's book and the Constellations from western civilization from the revised book Almagest on the Stellarium software showing some of the differences in the stars of its constellations is shown in Figure 4.

At first glance, the stars magnitude in al-Şūfi's work is similar to Ptolemy's. Al-Sufi identified a total of 134 additional stars, 65 stars located in the constellation North, 41 stars in the constellation Zodiac and 28 stars in the constellation South. His observations showed that the magnitude value of 520 stars out of a total of 1022 stars was identical between al-Sufi and Ptolemy. One may therefore wonder if al-Şūfi only estimated the magnitude of about half of the star observed by Ptolemy. Out of 520 stars, only 206 stars have a difference in value from modern visual magnitudes of more than 0.5 magnitudes, and only 56 stars with a difference in values from visual magnitudes of more than 1 Magnitude.



Figure 4. Illustrative comparison of constellations of Orion on Stellarium based on: Al-Sufi (left), Ptolemy (right)

The existence of Stellarium provides a solution to the mapping and designation of the stars recorded so that the mapping of constellations of stars in the night sky can be shown and studied well and conveyed to the current generation. With thorough mapping, researchers got more information such as more detailed stars being connected and visible from inside and outside of their constellations, the size of constellations in the night sky is well visible and some large constellation illustrations by al-Şūfi tend to overlay some of the illustrations next to them. The existence of celestial cultural features that can only be read in books, now can be observed and applied in sky simulations so that anyone can learn and develop in the future.

Conclusion

The kitab al-Kawākib al-Thābitah, later known as The Book of the Fixed Stars, contains an extensive catalog of stars, which lists star coordinates and approximate magnitudes, as well as star graphs and detailed constellation illustrations. The study of this book is often constrained in studying it because of the Language, understanding, and differences in the number of stars grouped in its constellations. Al-Sufi studied the work of Ptolemy and the book Almagest which was a mathematical and astronomical treatise, which detailed the movements of the Stars, Sun, Moon, and five known planets of that time. The Almagest includes a catalog with descriptions, positions, and magnitudes for 1022 stars grouped into 48 constellations for the time of 137 AD. This work became a standard star catalog used in the Western, Arab, and Islamic worlds for more than a thousand years. It contains stars and 48 complete star constellations by al-Şūfi. One of al-Şūfi's innovations in mapping stars was the production of double illustrations of each of Ptolemy's constellations: One illustration is depicted on the globe, and the other illustration is seen directly in the night sky. It is considered a unique feature of al-Şūfi's work. Al-Şūfi's work was based on Ptolemy's Almagest, so most constellation figures resemble classical style figures, but some figures undergo a process of orientalization as a result of the misunderstanding of some Greek mythological figures as well as copying errors in some versions of the Almagest. The transformation of the constellation style was also due to the influence of the Anwā' tradition. The constellation in the al-Şūfi work mentions many additional stars that are not included in the Ptolemy star catalog. However, al-Şūfi did not include these stars in his table although he identified many of them in detail and described their magnitude and he even estimated their location. In many cases al-Şūfi mentions that in some areas of the sky there are many stars but he fails to specify numbers because of their large numbers. Al-Sufi identified a total of 134 additional stars, 65 stars located in the constellation North, 41 stars in the

constellation Zodiac and 28 stars in the constellation South. The existence of Planetarium Technology and Software such as Stellarium provides a new way of presentation so that the current generation can study, explore, and convey back the science and work of Muslim astronomers who influence the world of Astronomy today and in the future.

References

- Al-Ajaji, Khalid. 2021. *Kitab Šuwar Al-Kawākib Al-Thamāniyah Wa-AlĀrba'een Karya Al Sufi*. Riyadh: King Fahd National Library.
- Amri, Zulfi., & Hadi, R. 2020. "Pembentukan Graf Berdasarkan Benda Langit (Bintang) Dengan Selisih Nilai Magnitude Tertentu." *Al-Marshad: Jurnal Astronomi Islam dan Ilmu-Ilmu Berkaitan*, 6(1): 24–34.
- Fernandez, L. 2019. "Arab Stars in the Castilian Sky: Al-Sūfī's Book of Fixed Stars amongst the Manuscripts of Alfonso X*." In *The Stars in the Classical and Medieval Traditions*, ed. Alena Hadravova. Prague: Institute of Contemporary History of the Czech Academy of Sciences.
- Hafez, I. 2010. *Abd al-Rahman al-Sufi and his book of the fixed stars: a journey of re-discovery*. [Thesis]. Australia: James Cook University.
- Lebling, R. 2010. "Arabic in the Sky." *Saudi Aramco World*, October: 24–33.
- Putraga, H. 2016. *Astronomi Dasar*. Medan: CV. Prima Utama.
- . 2020. "Nama Bintang Dari Kebudayaan Arab: Harta Langit Untuk Dunia." *OIF UMSU*: 1. <https://oif.umsu.ac.id/2020/06/nama-bintang-dari-kebudayaan-arab-harta-langit-untuk-dunia/>.
- Putraga, H., & Setiawan, H. R. 2018. *Stellarium & Google Earth - Simulasi Arab Kiblat Dan Waktu Salat*. Medan: UMSU Press.
- Qorib, M., Zailani, Z., Radiman, R., Amrizal, A., & Raisal, A. Y. 2021. "Pengembangan Media Pembelajaran Astronomi Rasi Bintang Untuk Anak Usia Dini." *Al-Marshad: Jurnal Astronomi Islam dan Ilmu-Ilmu Berkaitan*, 7(2): 162–68.
- Rakhmadi, A. J. 2018. *Esai-Esai Astronomi Islam*. ed. Gunawan. Medan: UMSU Press.
- . 2019. *Astronom Muslim Sepanjang Sejarah Peradaban Islam*. 1st ed. Yogyakarta: Penerbit Suara Muhammadiyah.
- Rice, D. S. 1959. "The Oldest Illustrated Arabic Manuscript." *Bulletin of the School of Oriental and African Studies*, 22(1): 207–20.
- Sela, S. 2016. "Al-Farghānī on the 48 Ptolemaic Constellations: A Newly Discovered Text in Hebrew Translation." *Aleph - Historical Studies In Science & Judaism*, 16(2): 249–365.