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Appraisal Of Bāb Zuwayla By Moḥammad Al-Nīlī: Description Of A Rare Astronomical Event

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Abstract:
ʿAlī bin Moḥammad al-Nīlī's appraisal of Bāb Zuwayla is a great example for a description of a building that combines elements of poetry, architecture, Quranic tradition, the history of the city of Cairo, as well as astronomy. Bāb Zuwayla is one of the still existing city gates in Cairo. Moḥammad al-Nīlī points out how the beauty of the building is highlighted by the culmintion of the Milky Way, Sirius and Saturn over it. At the same time he praises the Bāb in the framework of history and the Quranic tradition by referring to the Pharaonic times and the figure of Hāmān. Here we analyze Moḥammad al-Nīlī's appraisal and the remarks on it made by the Mamluk historian ʿAbd al-Zāhir and the 15th century encyclopedists al-Qalqashandī and al-Maqrīzī. We point out that a quasi-simultaneous appearance of the three celestial bodies over Bāb Zuwayla is a rare astronomical phenomenon and that the building phases of the first and second Bāb, as well as a later extension of the building, may be linked to it. Moḥammad al-Nīlī may have been triggered by one of the first two events to write the appraisal.

Keywords: *Bāb Zuwayla, Moḥammad al-Nīlī, Astronomy, Milky Way, Saturn, Sirius, ʿAbd al-Zāhir, al-Qalqashandī, al-Maqrīzī*

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I. Introduction

In many cases position, orientation and structure of architectural monuments were either determined by astronomical phenomena or interpreted in the framework of them. In addition to stars and the bright planets, the Milky Way is a very prominent structure in the sky. The nature of the Milky Way was debated for centuries. Observing the Galaxy from southern locations shows its prominence in the sky due to its extent and brightness. Early scholars had outlined its practical uses for temporal, geographical, and celestial orientation[1]. The traditional, scientific, and technical role of the Milky Way in the early Islamic society is summarized in an article by Eckart & Idris (2023)[2].

The Bāb Zuwayla has also been described in the framework the Milky Way, the star Sirius as well as the planet Saturn. Bāb Zuwayla is one of the city gates in Cairo which can still be admired today. In this context ʿAlī bin Moḥammad al-Nīlī's appraisal of Bāb Zuwayla can be taken as a great example for such a description of the building. He wrote this appraisal in the form of a poem that combines elements of poetry, architecture, Quranic tradition, as well as the history of the city of Cairo, and astronomy.

In this publication, we support our thesis that the astronomical facts described in Moḥammad al-Nīlī's poem represent a rather rare, but recurring configuration between the Bab Zuwaily building and the celestial objects Galaxy, Sirius, and Saturn. To do so, we must analyze the poem in the historical context of its various construction phases.

In the transliterations we use *j* and *īy*, instead of *ǧ* and *iyy*, as well as *sh*, instead of š. All translations were made or revised by the author himself. The research presented here draws upon texts from the 10*th* to the 15*th* century and used *al-Maktaba al-Shāmila*[3] to investigate the role of the Milky Way in the early Islamic society.

1 Andreas Eckart, "Use of the Galaxy as a Tool for Spatial and Temporal Orientation duringthe Early Islamic Period and up to the 15th Century," Arabic Sciences and Philosophy (ASP, Cambridge University Press, Cambridge, United Kingdom, 2021): 31, no. 1

2 Andreas Eckart & Mesut Idriz, "Knowledge of the Milky Way in the Arabic Cultural Region between the 8th and the 15th Centuries," Australian Journal of Islamic Studies (AJIS, Auburn NSW, Australia, 2023): vol.8, issue 3, 1-15

3 al-Maktaba al-Shāmila (Comprehensive Library) is a comprehensive open source collection of Arabic texts from early Islamic history until today, in open access at http://al-maktaba.org/. After initial electronic search we verified all references in copies of the printed texts.

Following the Introduction we present the historian Ibn ʿAbd al-Zāhir and the author of the poem Moḥammad al-Nīlī in section 2. In section 3 we give a brief rehersal of the complex history of Bāb Zuwayla. In section 4 we then present the poem by Moḥammad al-Nīlī as it is recited by several commentators we refer to. We also present the comments by Ibn ʿAbd al-Zāhir that accompany the verses. This is followed by the analysis of the poem in section 5. We explain elements of the historical and traditional context highlighted in Ibn ʿAbd al-Zāhir's comments and the poem in section 5.1. This includes an explanation of the term bāshūra as well as the persons mentioned by Moḥammad al-Nīlī, i.e., the *Pharaoh* and *Hāmān* as well as the *edifice* the author relates to. We then summarize the names and dates that are mentioned by differenct commentators with respect to the building process of the two differnt versions of Bāb Zuwayla in section 5.2. The astronomical elements of the poem like the Milky Way and Sirius as well as the unique properties of the celestial motion of the planet Saturn are explained in sections 5.3 and 5.4. This is followed by the description of the calculation of the culminations events over Bāb Zuwayla in section 6. Details of the location and orientation of Bāb Zuwayla are dealt with in section 6.1. In section 6.2 we explain how we calculate the culmination events and present the results of the calculation in section 6.3. In section 7. we discuss the possible envolvement of mysticism in the history of Bāb Zuwayla and finally present a summary and conclusions in section 8. Here, we show what can be drawn from our analysis with respect to the unknown lifetime of Moḥammad al-Nīlī and his motivation to write the poem. The final section is followed by the acknowledgements.

II. History Of Bāb Zuwayla

As we will investigate the linkage between an astronomical event and the erection and presence of the two versions of the city gate Bāb Zuwayla it is necessary to do a brief rehearsal of the history of the Bāb. Here, we do this closely linked to the reports on Bāb Zuwayla that are given by the ecyclopedians and historians al-Zāhir (1223–1293 CE, details given in the next section), al-Qalqashandī[4] (1355 or 1356-1418 CE), and al-Maqrīzī[5] (1364- 1442 CE) in reciting the verses of Moḥammad al-Nīlī. Further, more detailed information on the historical circumstances as well as on the other city gates is given by Creswell (1952)[6].

There are three remaining gates in the walls of the Old City of Cairo, Bāb Zuwayla is one of them. It is a major landmark of the city and the detailed history is complex.

After ruling from Ifriqiya, the Shi'a Isma'ili Fatimid empire conquered Egypt in 969. General Jawhar al Ṣiqilī[7] founded a new fortified city northeast of Fustat. It took four years to build the city that was initially known as al-Manṣūrīyah with a first prayer in the newly built Friday mosque in 971 CE. Imam-Caliph Abū Manṣūr Nizār ibn al-Muʿizz[8] (955-996 CE) arrived there in 972 CE and renamed the city in al-Qāhira[9] in 973 CE. Bāb Zuwayla opened an overland trade route with Zawīla, a village in the Fezzān region in southwestern Libya. During the European Middle Ages, it was the capital of that region and the Fatimids recruited soldiers from the area. Hence, the name 'Zuwayla' derives from the name of a tribe of Berber warriors in the western desert. Members of this tribe were responsible for guarding the gate. Integrated into the original city walls, the building was built in mudbricks. Hence, we can assume that this first version of Bāb Zuwayla was erected shortly after 969, but maybe as late as 973.

As the city was quickly growing the first version of Bāb Zuwayla was replaced by a second version between 1087 and 1092 as part of the new city wall about 100m to 130m south of the original location (Creswell 1952). It was built using stone and constructed along with the city gates of Bāb al-Futuh and Bāb al-Nasr that also still stand today. Hence, it is the last remaining southern gate from the walls of Fatimid Cairo in the 11*th* and 12*th* century[10]. During the Ottoman period it was also known as Bawābat al-Mitwalī.

4 Sheikh Abu al-Abbās Aḥmad al-Qalqashandī (short al-Qalqashandī ,1355 or 1356-1418 CE) was an Arab Egyptian encyclopedist, who showed expertise in multiple, diverse fields of study including mathematics. He was born in the Nile Delta, he became a scribe and clerk of the Mamluk chancery in Cairo, Egypt.

5 Taqī al-Dīn Abw al-ʿAbbās Aḥmad ibn ʿAlī ibn ʿAbd al-Qādir ibn Muḥammad al-Maqrīzī (short al-Maqrīzī, 1364- 1442 CE) was a Egyptian historian and biographer during the Mamluk era. He is well known for his interest in the history of the Fatimid era and even earlier periods.

6 Creswell, Sir Keppel Archibald Cameron, *The Muslim Architecture of Egypt. I. Ikhshids and Fatimids (A.D. 595-1171)* (The Clarendon Press, Oxford, Great Britain, 1952), 21-35, with page 26 and 27 on Bāb Zuwayla in particular.

7 Jawhār ibn ʿAbd Allāh (died in 992 CE) was a Sunni Fatimid general serving as viceroy of Egypt until al-Mu'izz's arrival in 973 CE, supporting the foundations for the city of Cairo.

8 Imam-Caliph Abū Manṣūr Nizār ibn al-Muʿizz (short al-Muʿizz, 955-996 CE) served as the fifth Caliph of the Fatimids and the fifteenth Imam of the Shia Ismailis. He was also known by his ruling name al-ʿAzīz biʾllāh.

9 Heinz Halm, *Das Reich des Mahdis. Der Aufstieg der Fatimiden (The Empire of the Mahdi: The Rise of the Fatimids"* (München, C.H. Beck Verlag, 1991): 368; and Jonathan M. Bloom, "Ceremonial and Sacred Space in Early Fatimid Cairo," in *Cities in the pre-modern Islamic world*, ed. Amira K. Bennison and Alison L. Gascoigne (London and New York, Routledge, 2007), 101. However, Creswell (1952) states that al-Maqrīzī is not very clear about this fact.

10 Heinz Halm, *Die Kalifen von Kairo. Die Fatimiden in Ägypten (973 - 1074) (The Caliphs of Cairo. The Fatimids in Egypt (973–1074))* (H.C. Beck, 2003), 19

Between 1415 and 1420, the Mamluk Sultan al-Mu'ayyad Shaykh[11] built his tomb mosque along with other charitable public institutions on the site of Bāb Zuwayla[12]. In 1419/20 the Bāb Zuwayla minarets were finalized. A third minaret collapsed already in 1427, was rebuilt but finally disappeared in the 19th century. A prison was close and executions took place at the gate. Although Bāb Zuwayla was originally built as a double gate, one of which was later removed because of growing superstition of the citizens. The remaining single gate without the minarets probably looked like the other two still remaining gates both erected in 1087/88. However, the original second Bāb Zuwayla would have combined round shape towers with two gate arches at the top that may have been added as part of its remodeling in the 15th century (see Creswell 1952).

III. The Historian Ibn ʿabd Al-Zāhir And The Poet ʿalī Bin Moḥammad Al-Nīlī

Ibn ʿAbd al-Zāhir (1223–1293) was an Egyptian historian during the Mamluk period. Several of his works covering letters and poems are still available today. Ibn ʿAbd al-Zāhir's work Kitāb al-rawḍah al-bahīyah al-zāhira fī ḫiṭaṭ al-muʿriba al-Qāhira is one of the important heritage books in geography, as it deals with a description of most of the landmarks of the city of Cairo[13].

This work has extensively been commented on by the later encyclopedist al-Qalqashandī (1355 or 1356-1418) in 'Kitāb Ṣubḥ al-Aʿshā' [14] and the even later by the historian al-Maqrīzī al-Maqrīzī (1364-1442) in 'al-Mawāʿiẓ wa-l-iʿtibār bi-dhikr al-khiṭaṭ wa al-athār'[15]. See also the work by El-Toudy & Abdelhamid[16].

IV. The Poem And Comments By Ibn ʿabd Al-Zāhir

In the following we present the statements on Bāb Zuwayla as given by ʿAbd al-Zāhir . We do not only present the poem by ʿAlī bin Moḥammad al-Nīlī but also the accompanieng comments on it by ʿAbd al-Zāhir and the editor of the 1996 First Edition by the Arab House for Books Library in Cairo. As we will see these comments contain information that relates to the poem and hence they are important to be mentioned in order to get a full picture of the verses by ʿAlī bin Moḥammad al-Nīlī. ʿAbd al-Zāhir writs in his work Kitāb al-rawḍah al-bahīyah al-zāhira fī ḫiṭaṭ al-muʿriba al-Qāhira (quoting from the 1996 First Edition, see earlier footnote):

وكل هذه الأبواب والسور كانت بالطوب اللبن.
وأما بابُ زُوَيْلَة الآن وباب النَّصْر وباب الفُتوح فبناها الأفْضَل أمير
الجيوش بن أمير الجيوش وكَتَبَ على باب زُوَيْلَة تاريخه واسمه وذلك في سنة
ثمانين وأربعمائة.
وقال إبن عبد الظاهر : أنشدنا الشيخ الشريف قال : أنشده علي بن محمد
النيلي لنفسه:
يا صاح لو أبصرت باب زويلة ... لعلمت قدر محله بنيانا
باب تأزر بالمجرة وارتدى الشعرى ... ولاث برأسه كيوانا
لو أنَّ فِرْعَوْنًا رآه لم يُرد ... صَرْحًا ولا أوْصَى به هَامَانَا
وقال إبن عبد الظاهر أيضًا : باب زُوَيْلَة بناه العزيز وتَمَّمَه بَدْرُ الجمالي (
في سنة أربع وثمانين)
قال المهندسون : إن في باب زُوَيْلَة عَيْبًا لكونه ليست له باشُورَةٌ تُدَامُه
ولا خَلْفُه على عادة الأبواب.

Translation*: "And all these gates and the wall were made of mud bricks. As for Bāb Zuwayla now, Bā al-Nasr and Bāb al-Futuh, they were built by al-Afdal, Amir al-Juyūsh bin Amir al-Juyūsh, and he wrote on Bāb Zuwayla his name in the year four hundred and eighty.*

Ibn ʿAbd al-Zāhir said: The Shayḥ al-Sharīf[17] *recited it to us. He said ʿAli bin Moḥammad al-Nīlī recited it to himself:*

My friend, if you see Bāb Zuwayla,
you will appreciate its worth as a building.

11 Al-Mu'ayyad Shaykh (1369 - 1421) was a Mamluk sultan of Egypt who ruled from 1412 till 1421. Al-Mu'ayyad was a major patron of Mamluk architecture in his era. He built or restored several buildings in and around Cairo.

12 Doris Behrens-Abouseif, *Cairo of the Mamluks. A History of the Architecture and Its Culture* (The American University in Cairo Press, Cairo, Egypt, 2007), 241

13 Ibn ʿAbd al-Zāhir al-Miṣrī, *Kitāb al-rawḍah al-bahīyah al-bāhira fī ḫiṭaṭ al-muʿriba al-Qāhira (The magnificent garden in the plans of the Arabized Cairo),* (First Edition, Arab House for Books Library, Cairo, Egypt, 1996), 62

14 Sheikh Abu al-Abbās Aḥmad al Qalqashandī, *Kitāb Ṣubḥ al-Aʿshā (The Dawn of the Blind)* (third part, Dā al-Kutub al-Khadawīa, Amīrī Press, Cairo, Egypt, 1914), 353

15 Taqī al-Dīn Abw al-ʿAbbās Aḥmad ibn ʿAlī ibn ʿAbd al-Qādir ibn Muḥammad al-Maqrīzī, *al-Mawāʿiẓ wa-l-iʾtibār bi-dhikr al-khiṭaṭ wa al-athār (Sermons and considerations by mentioning plans and effects)* (Dār al-Kutub al-ʿIlmīya, Beirut, Libanon, 1998), first edition, part 2, 240

16 al-Qalqashandī, *Selections from Ṣubḥ al-Aʿshā, Clerk of the Mamluk Court,"* ed. Heba El-Toudy and Tarek Galal Abdelhamid (Routledge, Oxon GB and New York USA; Series: Routledge Medieval Translations, 2017), 71-78

17 Meant is possibly a nephew of *Ibn ʿAbd al-Zāhir*: *Nāṣir al-dīn Shāfiʿ bin ʿAlī bin ʿAbbās al-kinānī al-ʿasqalānī al-masrī* (1251 - 1330), was an Egyptian writer, poet, historian, and military commander.

A gate that enveloped itself with the Galaxy, wore Sirius,
and wrapped Saturn around its head.[18]
Had the Pharaoh seen it, he would not have wanted
[any other] edifice [than this], nor would he have
ordered Hāmān to build him one.
[Ibn ʿAbd al-Zāhir also said: Bāb Zuwayla was built by al-Aziz and completed by Badr al-Jamālī in the year eighty-four]. The engineers said: There is a defect in the Zuwayla Gate, because it does not have a curved entrance in front of it or behind it, as is the custom for doors."

Further details of the text above in relation to quotations of the poem by other authors will be given in the next section.

V. Analysis Of The Poem

We now evaluate information from the poem and its commentaries that allows us to extract the construction date and geometrical orientation of the Bāb the poem relates to and then link this to the astronomical facts.

Historical And Traditional Context

In addition to the names and dates that can be linked to the history of Bāb Zuyaila, there are also other historical and traditional elements that are worth being mentioned. They regard property and appearance of the building.

The term bāshūra: The term bashūrah was apparently important to all three commentators that have passed down the verses of Moḥammad al-Nīlī. As explained in 'Mamluk Fortifications of Egypt' by Stephane Pradines[19] the term bashūrah refers to a barbican in front of a door; A barbican (from Old French: barbacane) is a fortified outpost or fortified gateway, used for defensive purposes[20]. Hence, what is most likely meant is a curved entrance to stop or hinder the enemy to enter the city through the gate. As an example: The main entrance gate, the Gate of Justice (also known as Gate of the Esplanade), of the Alhambra in Granada, Spain, has such a curved gate entrance.

Apparently not everyone shared Moḥammad al-Nīlī's effusive assessment of B*āb* Zuwayla. The engineers represent a significant shortcoming of the building's function as a fully-fledged city gate. This suggests that Moḥammad al-Nīlī was only concerned with the building's external appearance (and its linkage to celestrial phenomena) and neglected the elements of functional architecture.

The Pharaoh, Hāmān, and the edifice: Hāmān is a character mentioned in the Quran. There, he appears as a high priest and a official of the pharaoh's court. This happens at the time of the Israelite prophet, Moses, i.e., at the time the pyramides were built. The mention of *Hāmān* allows us to make statements about the building material (stone or mud brick) of the B*ā*b and thus to determine the time of erection of the respective version of the B*ā*b to which the poem refers. The use of bricks by the pharaohs in erecting buildings is suggested by the Sūrah al-Qaṣaṣ [Quran 28:38]. Here, the pharaoh asked Hāmān to build him a building of baked clay. Hence, the edefice mentioned in al-Nīlī's poem may relate to the Quranic description of the large buildings the Pharaoh's ordered to be built and Moḥammad al-Nīlī claims that Bāb Zuwayla is even more impressive than those.

VI. Sorting The Names And Dates

The above verses by Moḥammad al-Nīlī are passed down to us by al-Zāhir, al-Qalqashandī, al-Maqrīzī. In the accompanying comments they refer to each other in chronological sequence and it is unclear if the latter two gathered information on the building times of the gates independent from the information by the very first author. The authors also often use different names or short forms of names for the same person. As we need to firmly link the various building phases of Bāb Zuwayla to dates we have a closer look to the names and facts mentioned by the authors listed above. The picture that emerges is the following:

Al-Qalqarshandī notes that Jawhār, likely referring to Jawhār al-Ṣiqilī (died in 992 CE), had planned four city gates, including Bāb Zuwayla. al-Maqrīzī mentions that al-Zāhir attributes the construction of Bāb Zuwayla to al-ʿAzīz Billah Nizār ibn al-Muʿizz (955-996 CE). While al-Zāhir refers to this ruler simply as al-

18 Instead zuḥal the Persian synonym kaywān has been used.
19 Stephane Pradines, "Mamluk Fortifications of Egypt," in *Mamluk Studies Review vol.19* (University of Chicago), 1-54
20 It is possible that the term bāshūra has old Egyptian roots. The first tow letters could be identified as a determinative article *pa* leading a word for a wall, gateway or stop-up sh*rı* (Sir Alan Gardiner, "Egyptian Grammar" (London 1973), p.595 (the word), p.496 (the determinative article). Fatma Farag Abdelhay (Leuven / Ghent University), private communication.

ʿAzīz, al-Maqrīzī provides further details to the name. Abū l-Manṣūr Nizār ibn al-Muʿizz served as the fifth Caliph of the Fatimids and the fifteenth Imam of the Shia Ismailis from 975 CE until his death, ruling under the name al-ʿAzīz billah, often mentioned only as al-ʿAzīz. Hence, al-ʿAzīz building Bāb Zuwayla must relate to the first version of the Bāb which must have been erected shortly after 970 CE.

The Armenian Abū'l-Najm Badr ibn ʿAbdallah al-Jamālī al-Mustanṣirī (1005/8- 1094 CE), also known as Badr al-Jamālī or, in our texts also refered to as, Amīr al-Juyūsh (Commander of the Armies), was a Fatimid statesman and military leader under Caliph Abū Tamīm Maʿad al-Mustanṣir biʾllāh (1029-1094 CE), who was the eighth Fatimid Caliph from 1036 until 1094 CE. Badr al-Jamālī became the vizier in 1073 CE and effectively ruled the country as a dictator under the nominal authority of al-Mustanṣir.

Al-Zāhir states that Bāb Zuwayla was constructed by al-ʿAzīz and completed by Badr al-Jamālī in the year 484h (1091/92 CE). Additionally, al-Zāhir mentions that Amīr al-Juyūsh bin Amīr al-Juyūsh (referring to Badr al-Jamālī) inscribed his name on Bāb Zuwayla in the year 480h (1087/88 CE). Al-Maqrīzī confirms that Bāb Zuwayla was built in 484h (1091/92 CE) and that Bāb al-Futūḥ was constructed in 480h (1087/88 CE). Al-Qalqashandī writes

فهدم ثم ابتنى أمير الجيوش بدر الجمالي المتقدّم ذكره
في سنة ثمانين وأربعمائة سورا من لبن دائرا على القاهرة

Translation: *"Then, in the year 480h, the Commander of the Armies, Badr al-Jamālī, who was mentioned [above], demolished [it] and built a wall of mud bricks surrounding Cairo."*

If one takes these dates at face value, Badr al-Jamālī apparently not only completed the city walls, erected the second Bāb, engraved his name on it and thus inaugurated it, but also destroyed the first Bāb along with it. The short time difference between demolition and re-erection also suggests that the bricks or any other building material of the first Bāb may have been reused for the second Bāb.

The Star Sirius And The Milky Way

In the appraisal of Bāb Zuwayla al-Nīlī mentiones that it is a gate that "... enveloped itself with the Galaxy" and "wore Sirius ...". Meant is most likely the bright star α Canis Majoris today also named Sirius A, culminating over the Bāb. It has a right ascension of α= 06*h* 45*m* 08.917*s* and a declination of δ= -16° 42‘ 58.017". Its apparent magnitude in the visual band of m_V =-1.46 makes it a bright object well observable in northern winter. It is part of the prominent Winter Triangle comprising Sirius, Betelgeuse, and Procyon.

Sirius is located in the sky projected body of the Milky Way. For a southern location like Cairo, in winter the sections of the Milky Way that are toarwds the quadrants including the Galactic anti-center are visible. Especially a northern and a southern section stand out (see Fig.2 in Eckart et al. 2018) and are bright and particularly well observable close to midnight when these sections are highest. If Sirius is culminating, then the southern section of the Milky Way close to the anti-center will stand high above the horizon and will cover a major portion of the sky, such that Bāb Zuwayla appears to be engulfed in it as discribed by Moḥammad al-Nīlī.

The Retrograde Motion Of Saturn

In the appraisal of Bāb Zuwayla al-Nīlī also says that the gate "wrapped Saturn around its head". We suggest that this points at the exceptional, curved apparent motion of Saturn in the sky. The siderial orbital period of Saturn is 29.4475 years[21]. With this high precision, we can in principle date culmination events over 1000 years back to within a few tens of days. This allows us to confidently verify the thesis formulated in our introduction that Muhammad al-Nīlī's poem represents a rather rare but recurring constellation between the Bāb Zuwayla building and the celestial bodies mentioned. The apparent motion of Saturn in the sky turns retrograde for about 135 days each year. It usually moves into retrograde motion for a total angular section of up to 8^o to 9^o during its cycle. At midnight in winter the center of its retrograde motion can be found towards the south on the meridian culminating over Bāb Zuwayla.

Al-Nīlī links the different astronomical phenomena using the conjunction *wāu*. Here, we may assume that this "and" in al-Nīlī's poem is an inclusive, logical 'AND' – indicating that the events are assumed to be occuring simultaneously.

In that case we have to differenciate between the first and the second Bāb Zuwayla - a detailed discussion followes in the next section. The exact observed aspect angle will of course depend on the position of the observer with respect to the Bāb. In the narrow street that leads to the gate from the city center this may induce a typical uncertainty of up to about 10^o depending on the distance to the gate.

21 Williams, David R. (23 December 2016). Saturn Fact Sheet. NASA. Archived from the original on 17 July 2017. Looked up for use in this publication 12 March 2025. https://nssdc.gsfc.nasa.gov/planetary/factsheet/saturnfact.html

VII. Calculation Of The Centering Events

Now that we have information about the construction dates of the two Bāb versions and the astronomical boundary conditions, we can turn to the more precise geomatric orientation of the respective Bāb Zuwayla versions and the calculation of the centering events.

Location And Orientation Of Bāb Zuwayla

Since we will link the astronomical culmination events of the Milky Way, Saturn and Sirius with the physical presence of Bāb Zuwayla, it is essential to discuss the exact location and in particular the orientation of the Bāb.

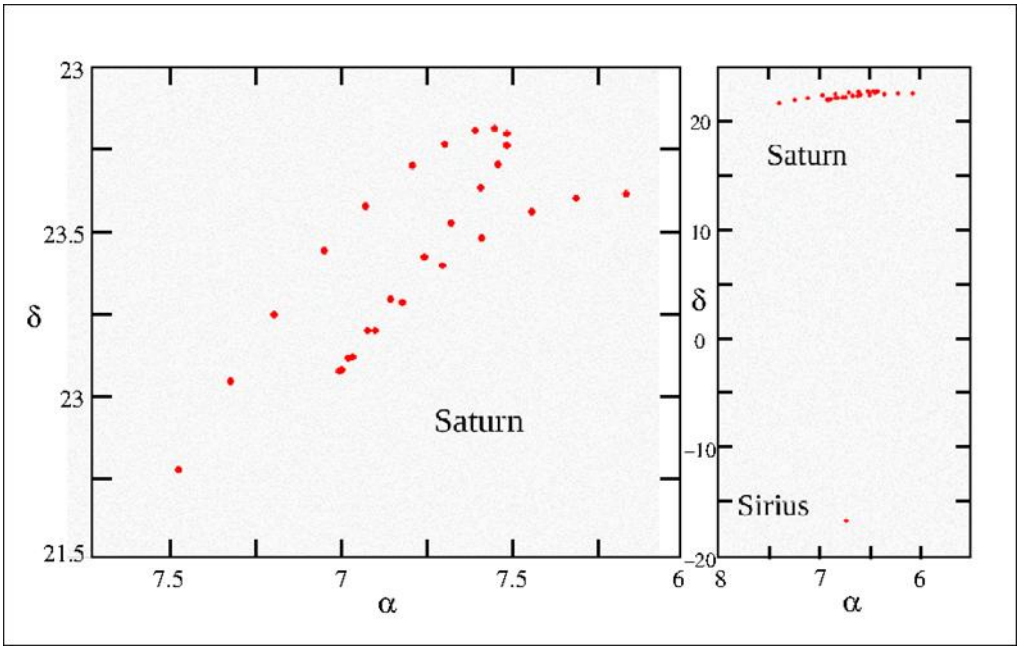

Figure 1: Sirius culminating towards the south on the meridian at midnight over the first Bāb Zuwayla for June 2003 till July 2004 – with Saturn passing the center of its retrograde motion. On the left we show the Saturn track at a higher resolution. Selected positions equidistantly in time (~15 days each) are shown as red dots. On the right we show Sirius cumlinating at the reference epoch on the meridian and Saturn in the time before and after. Sirius is engulfed in the Milky Way (not shown here). Bāb Zuwayla would be located below Sirius. Here, we show the situation in right ascension and declination (α, δ). During the period of retrograde motion, the observer will see the track in the same shape when observing it every midnight in azimuth and elevation.

As a reference case for the more southernly oriented first Bāb Zuwayla, Saturn and Sirius culminate on the southern meridian well above the Bāb. While the exact appearance of the two celestrial bodies over the Bāb depends on the time and the position of the observer relative to the Bāb we chose as a refernce time (without loosing generality of the result) always midnight. The observer must position himself always at a distance of several 10 meters away from the Bāb such that Sirius is well visible. In Fig.1 we show how the situation looks like in the references case at midnight over the first Bāb Zuwayla – with Saturn at the center of ist retrograde motion. If we want to know how the situation was at earlier times in history we use the reference epoch[22] (see following section for details) in December 2003 from which we can count backwards (see next section).

For the second Bāb Zuwayla the situation is a bit different as the Bāb is orientated significantly towards the south west. Here, the street Ahmed Maher towards the west and El-Darb El-Gadid to the East follow the direction of the old city wall that enclosed the Bāb. Inside the wall towards the north we have the street Al Moez Ldin Allah. Being on that street at a fair distance from the gate Sirius and Saturn will be very prominent once they position themselfs above the Bāb. As an average value of the aspect angle for any observer

22 We use reference epochs for the location of Cairo in December 2003 (local time 2003 Dec. 17 midnight) for Saturn's culmination on the meridian together with Sirius, such that Saturn is close to the center point of its retrograte motion, and January 2005 (local time 2005 Jan. 07 midnight) for Saturn, close to the center point of its retrograde motion, when it is positioned above Sirius at 23° west of the meridian. We have chosen 23° as a representative value in order to approximate the orientation of the two Bāb Zuwayla versions. For the ephemeries see see https://in-the-sky.org/

watching the night sky towards Bāb Zuwayla we chose a value of 23^o between the true orientation of the Bāb and the orientation of the narrow street from the city center towards it. Since the second Bāb Zuwayla is oriented towards the south west - and of course depending on the aspect angle of the observer - Sirius will stand above it about one and a half hours after it went through the meridian. So it will have a slightly lower elevation as well. In order for Saturn to position itself above Sirius while positioning itself over the Bāb, Saturn must go through culmination about one to two hours later than Sirius.

Creswell (1952) argues that close to an old Turkish *sebīl* and about 130 m north of todays Bāb Zuwayla on the maps available to him (Survey of Egypt 1947 (47/131)) the two parallel streets, he gives their names as *Shāriʿ al-Manākhlīya* and *Shāriʿ al-Munaggidīn*, are very closely together such that they 'surely' must represent the axis (i.e. orientation of the line connection two towers of the gate) of the first Bāb Zuwayla. In todays maps we find at that position, i.e., at the same distance north of todays Bāb as mentioned by Creswell, an east-west kink in *Shāriʿ al-Minajidīn* opposite of the *sebīl Muḥammad ʿAlī Pāshā*. Following the maps presented by Creswell (1952), the proposed course of the city wall is mostly east-west slightly inclined to the north by about 15^o while stretching out to the west. Hence, it seems that the first gate was oriented such that the path through it was approximately pointing to the south when exiting the city. As can be seen from the present building and from sketches of the floor plan of the building structure, the orientation of the new second gate is significantly tilted by about 30^o towards the north while streching out to the west. The year 84h reported by Ibn ʿAbd al-Zāhir, in which Badr al-Jamālī completed the second gate does not fit to any of the dates above and could be a copying mistake, i.e. 84h instead of 480h.

For the second Bāb Zuwayla the situation is a bit different as the Bāb is orientated significantly towards the south west. Here, the street Ahmed Maher towards the west and El-Darb El-Gadid to the East follow the direction of the old city wall that enclosed the Bāb. Inside the wall towards the north we have the street Al Moez Ldin Allah. Being on that street at a fair distance from the gate Sirius and Saturn will be very prominent once they position themselfs above the Bāb. As an average value of the aspect angle for any observer watching the night sky towards Bāb Zuwayla we chose a value of 23^o between the true orientation of the Bāb and the orientation of the narrow street from the city center towards it. Since the second Bāb Zuwayla is oriented towards the south west - and of course depending on the aspect angle of the observer - Sirius will stand above it about one and a half hours after it went through the meridian. So it will have a slightly lower elevation as well. In order for Saturn to position itself above Sirius while positioning itself over the Bāb, Saturn must go through culmination about one to two hours later than Sirius.

The Culmination Events

We can calculate when quasi-simultaneous centering events of the Milky Way, Saturn and Sirius take place over Bāb Zuwayla. Since the Bāb is engulfed in the silhouette of the Milky Way when Sirius is culminating over it, we only have to consider Sirius and Saturn. These culmination events, i.e., a minimization of the azimuth angle difference between the two celestrial bodies, occur over the different Bāb-versions every 29 to 30 years[23]. Instead of using the full ephemeries, which are hardly available at high cadence for the entire period of interest, we have chosen a simpler quasi-analytical approach to our problem, which yields useful results near the meridian. Our results are good in agreement with those that can be derived by the public free planetarium programm *Stellarium*[24] that can be consulted via the internet.

First we find a reference epoch T close to our current date in which the azimuth angle of Sirius is close to that of the center of Saturn's retrograde motion (e.g. from published ephemeries or *Stellarium*). Then we calculate for each year the difference in azimuth angle between Sirius and Saturn. For observations at midnight the hour angle of Sirius is 180^o at the time of its culmination on the meridian. Starting from the reference epoch Saturn progresses on the ecliptic for each year by 360^o/P with the period of P = 29.4475 years. At midnight the ecliptic is perpendicular to the meridian. This implies that before and after culmination the angular motion of the planet for in the ecliptic results in good estimates for the angular distance from the meridian. Hence, the mathematical procedure can be reduced to a modulo discription:

$\Delta = n * 360/P - m * 360$

with n counting the years and m incrementing for each new orbit in integers starting from 0, such that the result Δ lies in the interval between -180^o and 180^o (i.e., Saturn can be east or west of Sirius). The retrograde

23 While quasi-simultaneous culminations of Sirius and Saturn occur over the different Bāb-versions, there is another quasi-periodicity that should be mentioned. Given the nature of the the siderial orbital period of Saturn of 29.4475 years as a broken number there is a ~280 year period within which the right ascension separations between the Sirius and Saturn become smallest. However, this event does not necessarily take place during culmination on the meridian, and even if it occurs close to the medidian it is difficult to distinguish this from the events occuring every 29 to 30 years in which the azimuth angles of the two celestrial bodies match very closely.

24 https://stellarium-web.org/; With the online version created by Fabien Chereau and his brother Guillaume. We used the version 24.4; (22. Dezember 2024)

motion covers t_{retro}=135 days[25], and is spanning up to 9^o of angular distance in the sky. With this methode we are not resolving the retrograde motion of Saturn but always relate to culmination events with Saturn close to the center point of its retrograde motion, i.e. close to the meridian - as set by the choise of the reference epochs[26]. Hence, the quantity *abs*(Δ) is a useful measure of Saturns proximity to the meridian close to culmination of the planet. To obtain the final value of abs(Δ), we follow the Julian date calculation, taking into account the effects of leap days and the shift from October 4 (Julian date) to October 15 (Gregorian date) introduced by Pope Gregory XIII in 1582.

Uncertainties of the Results: Our reference epochs for observation have been chosen to be close to midnight. In this case we do not have to consider parallax effects since the observation will always be along the radius vector from the Sun to the Earth towards Saturn very close the meridian. The position of Sirius in the sky changes with time. For the star Sirius the proper motion (μ) in the sky is -546.01 mas/yr[27] in right ascension and -1,223.07 mas/yr in declination. At a distance of 8.60 ± 0.04 ly Sirius' parallax (π) is 379.21 ± 1.58 mas. This imposes positional changes of the order of a degree over 1000 years. Postional shifts also occur due to the precession of the Earth's spin axis. Here, only the differential precession between the position of Sirius between reoccuring conjunctions with Saturn over Bāb Zuwayla need to be considered. The positioning of Saturn may also be a source of uncertainties. For the planet Saturn the uncetrainties in the orbital period of 29.4475 years we assume to be of the order of 0.0001 years, i.e., 0.88 hours. In total, backdating todays astronomical event over a 1000 years, a very conservative estimate of the total uncertainty of our simple analysis is a fraction of a month[28], fully sufficient to discuss the linkage to the building phases of Bāb Zuwayla.

VIII. Results Of The Calculation

The result plot is shown in Fig.2. Here, we plot the absolute angular distance of Saturn on the ecliptic from the meridian at midnight. Since the first and second Bāb versions are tilted towards the north while streching out to the west, we investigated two scenarios: the first scenario is the one in which the quasi-simultaneous culmination takes place on the meridian and one in which Saturn is positioned above Sirius as Sirius is located at an azimuth angle of 15^o to 30^o west of the meridian, such that the observer experiences the effect of being placed at an angle of 90^o in front of the Bāb. Culmination of Saturn over Sirius at a separation from the meridian of, e.g. 23^o occur in the year 976.37 with *abs*(Δ) = 2.6758^o and in the year 1093.27 with *abs*(Δ) = 0.1084^o. These events cleary occur later than the start of the various building phases of Bāb Zuwayla. Also Sirius is not at its well defined location with the highest altitude above the horizon.

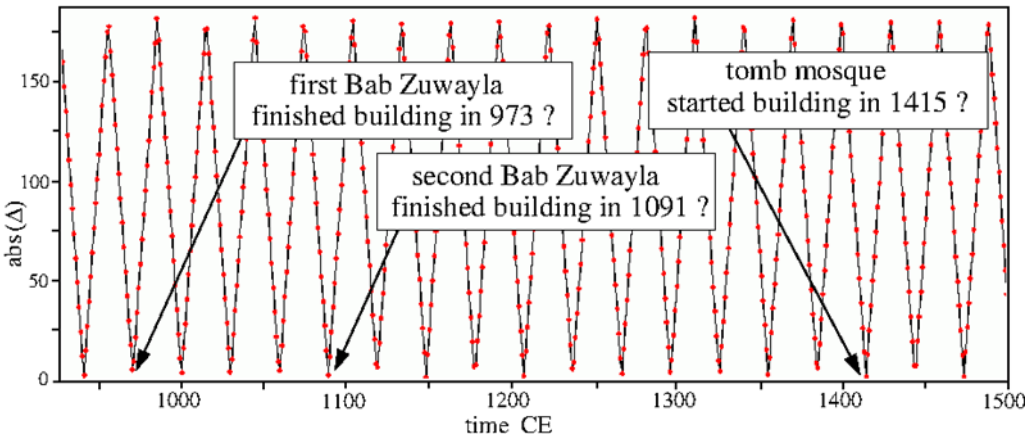

Figure 2: Here, we plot our simple estimates of the absolute angular distance abs(Δ) (in degrees) as a measure of Saturn's distance on the ecliptic from the meridian at midnight. We highlight the building events (and their probabel dates) during the minima of that distance as mentioned in the text.

Clearer defined are quasi-simultaneous culminations of Saturn, Sirius and the Milky Way that take place close to the meridian (i.e., *abs*(Δ) very close to 0^o) in the year 973.01 with *abs*(Δ) = 4.12^o and in the year 1091.01 with *abs*(Δ) = 1.557^o. This implies that a culmination event took place in ~973 close to the completion

25 This is less than 1.3 hundredths of its orbital period

26 Corrections for the fact that the motion of Saturn on its orbit is treated on the ecliptic as a heliocentric motion where as the observation is geocentric are not taken into account. For separations of +/-10^o from the meridian (i.e. fully including the total angular section of Saturns retrograde motion up to 8^o to 9^o) this effect amounts to an uncertainty of only about 1^o or less. Hence, close to meridian it can be neglected for or argumantation.

27 angular velocity in milliarcseconds per year

28 Backed by analyses using more suffisticted public free planetarium programms like, e.g., Stellarium

of the fortification of the city of al-Manṣūrīyah by General Jawhar al Ṣiqilī and right in the same years in which Imam-Caliph ibn al-Muʿizz renamed the city of al-Manṣūrīyah in al-Qāhira. Only four Saturn orbits later, in ~1091, a further quasi-simultaneous culmination event took place which again falls very close to or even together with the year 484h (1091/92 CE) in which the construction of the new Bāb Zuwayla, now made out of stone, was completed by Badr al-Jamālī. It is interesting to note that a further culminatioin event took place in 1415, when the Mamluk Sultan al-Mu'ayyad Shaykh started to build his tomb mosque, four to five years before the Bāb Zuwayla minarets were finalized.

The probability estimate for each one of the individual building phases of Bāb Zuwayla as well as the start of building the tomb in the 15th century, to fall together with a quasi-simultaneous culmination event is about 1 yr/t_{orbit} ~ 1/29. In order to determine the combined probability of three such independent events happening, we multiply the probabilities of all three and obtain a value of 4×10^{-5}. This value is much smaller than unity. Hence, it appears to be highly unlikely that the astronomical event of a quasi-simultaneous culmination of Saturn, Sirius and the Milky Way was not considered for all of these building events.

IX. Envolvement Of Mysticism?

Superstition and mysticism have been part of Bāb Zuwayla's history from the very beginning. This was supported not least by the use of the location for public executions and the associated fear among the population. Throughout the centuries, the Bāb Zuwayla was the scene of cruel executions and beheadings. This is documented for the second gate until the 19th century[29] [30] Originally, the first version of the Bāb had two gates. The left gate fell into disrepute due to widespread popular superstition and was eventually walled up[31].

In many cases propitious moments of building phases of architetual monuments were chosen by the astrologers. Under the Fatimids mysticism played a certain role and the assistance of astrologers was involved in the determination of the exact start of the building works. As Creswell (1952) points out, in the case of the foundation of Cairo (and hence, the city walls and the corresponding gates) the story is that a crow had given a false signal to the workmen to start and apparently at that time Mars happened to be in the ascendent which was a bad sign for the project. However, Creswell points out that the same narrative was told for the foundation of the city of Alexandria by Alexander the Great. This happened well before mentioning the story with respect to the foundation of Cairo. Hence, his story is banned into the realm of a legends by Creswell.

However, the results of our analysis allows to re-evaluate the role of mysticism in the case of Bāb Zuwayla. We find that building phases may have been linked to the quasi-simultaneous culmination of Saturn, Sirius and the Milky Way. Etymologcally the names for Saturn, *zuḥal*, or the Persian synonym *kaywān* used by Moḥammad al-Nīlī refer to the fact that Saturn is the classically known planet with the slowest motion in the sky[32]. In Roman and Greek mythology this fact made Saturn being the god of time with linkages to dissolution but also to abundance, wealth and periodic renewal and liberation. Sirius often has been linked to brilliance and enlightenment. Likewise, the Milky Way is laden with mystical interpretations that may have been relevant to the thinking of people at the time of erecting different versions of Bāb Zuwayla. In Greco-Roman and Egyptian mythology, the Milky Way was associated with fertility. In particular, Greek mythology states that Saturn's wife provided her children with milk (Ultimately, she could only saved Jupiter from being devoured by his father, Saturn)[33]. Hence, it cannot be excluded that this plethora of mystical interpretation was used to put the future and well-being of the Bāb as well as the city in a favorable light.

X. Summary And Conclusions

For the erection of the two different versions of Bāb Zuwayla quasi- simultaneous culminantions of Saturn, Sirius and the Milky Way ocurred also during the Islamic Golden Age and certainly caught the interest of the researchers and rulers at that time.

29 Caroline Williams, *Islamic Monuments in Cairo: The Practical Guide (7th ed.)* (The American University in Cairo Press, Cairo, Egypt, 2018), 189–192

30 Carl F. Petry, *The Mamluk Sultanate: A History* (Cambridge University Press, Cambridge, United Kingdom, 2022), 52

31 Oleg V. Volkoff, *1000 Jahre Kairo. Geschichte einer verzaubernden Stadt (1000 years of Cairo, History of an enchanting city)* (Verlag Phillip von Zabern, Mainz, Germany, 1984), 68

32 Wilhelm Eilers, *Sinn und Herkunft der Planetennamen (Meaning and origin of planetary names) (*Verlag H. C. Beck & Verlag der Bayerischen Akkademie der Wissenschaften, Munich, Germany, 1976), 88-97

33 Gaius Julius Hyginus, *The Poeticon astronomicon: being the illustrious astronomer's exposition of the lore of the world and the heavenly sphere,together with the stories of the planets and constellations* (Erhard Ratdolt, Venice, Italy, October 14, 1482), chapter 43, vol. book 2, with Latin verses contributed by J. L. Santritter and Jacobus Sentinus, translation into English, based on Ratdolt's edition and corrected against Bernhard Bunte's variorum edition (Leipzig, Germany, 1875), by Mark Livingston, B.A. Williams College, assisted by D. Neel Smith, Ph.D. cand. (classics), University of California, Berkeley. English translation available under: https://archive.org/details/ap_20200203 .

The historian al-Zāhir points out that the first city wall and the city gate Bāb Zuwayla were built in mudbricks. Also Moḥammad al-Nīlī involves Hāmān, who had been building for the pharaoh using bricks made from baked clay. This suggests that Moḥammad al-Nīlī is referring to the first version of the Bāb. If he had been referring to the second Bāb built of stone he probably would have included that as a positive fact in his appraisal and a reference to Hāmān as a mudbrick builder would not have been appropriate.

We have shown that Moḥammad al-Nīlī's poem most likely describes a rather rare, but recurring quasi-simultaneous culmination of the celestial objects Galaxy, Sirius, and Saturn over the first Bab Zuwaily building as stated in our initial thesis presented in the introduction. The fact that the probabel finalization of the fortification of the city of al-Manṣūrīyah and the renaming of it to al-Qāhira fall in the same year of a quasi-simultaneous culmination in 973 CE may suggest that Moḥammad al-Nīlī's appraisal was not only triggered by the astronomical event and the magnificence of the building. The poet may very well have been triggered to write the appraisal by the Imam-Caliph Abū l-Manṣūr Nizār ibn al-Muʿizz personally or by the administrative staff close to him. This could also explain why the functional drawback of the building - namely not having a bashūrah - is suppressed in al- Nīlī's appraisal. Assuming a total lifetime for the poet of 60 years and placing his active writing time at the middle of it, ʿAlī bin Moḥammad al-Nīlī must have been living approximately between 943 CE and 1003 CE. It is, however, still unclear who he was and what other contributions to literature he may have made.

Hence, we find that al-Nīlī's appraisal of Bāb Zuwayla is a great example of a text that combines several elements: poetry, architecture, history of the city of Cairo, astronomy including the star Sirius, Saturn, and the Milky Way, as well as refering to Quranic tradition.

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