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Suhayl

International Journal for the History of the Exact
and Natural Sciences in Islamic Civilisation

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Contents

REVIEWS

al-Ashraf ʿUmar's Tabṣira, *Chapter xxiii: Timekeeping at Night by the Moon in 13th-Century Yemen and Beyond*

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Abstract: This article explores methods for determining moonrise and moonset as evidenced within a range of pre-and early modern sources originating from Islamicate societies. The idea emerged during a workshop in July 2022 where a talk by the first author on Ibn Waḥshiyya's moonrise-moonset text in his *al-Filāḥa al-Nabaṭiyya* («The book of Nabatean agriculture») and the second author's project on the *Kitāb al-Tabṣira fī ʿilm al-nujūm* («Book of enlightenment in the science of the stars») by al-Ashraf ʿUmar revealed overlaps. Given the resemblances observed in the two sources, chapter xxiii of *Tabṣira* has been selected as the initial reference point for tracing the technique across additional sources. It is important to note that this examination does not assert comprehensiveness, nor does it account for the reciprocal interdependencies among the examples presented. Nevertheless, the present article suggests a categorisation of the diverse methods predicated on various factors such as exactitude, complexity, state of completeness, literary formats, and audience.

Keywords: al-Ashraf ʿUmar; *Tabṣira*, Ibn Waḥshiyya; *al-Filāḥa al-Nabaṭiyya*; timekeeping; Moon, calendars.

Resum: Aquest article explora els mètodes per determinar la sortida i la posta de la lluna, tal com s'evidencia en una sèrie de fonts premodernes i de l'inici de la modernitat provinents de les societats islàmiques. La idea va sorgir durant un taller el juliol de 2022, on una xerrada del primer autor sobre el text de la lluna i la posta de la lluna d'Ibn Waḥshiyya a *al-Filāḥa al-Nabaṭiyya* («El llibre de l'agricultura nabatea») i el projecte del segon autor sobre el *Kitāb al-Tabṣira fī ʿilm al-nujūm* («Llibre de la il·luminació en la ciència de

Mousavi, Razieh S. & Schmidl, Petra G. (2023). «al-Ashraf ʿUmar's *Tabṣira*, Chapter xxiii: Timekeeping at Night by the Moon in 13th-Century Yemen and Beyond». *Suhayl. International Journal for the History of the Exact and Natural Sciences in Islamic Civilisation*, 20, December 2023, pp. 7–42. ISSN: 1576-9372. DOI: 10.134/SUHAYL2023.20.1.

les estrelles») d'al-Ashraf ʿUmar, va revelar superposicions. Donades les semblances observades a les dues fonts, s'ha seleccionat el capítol xxiii de *Tabṣira* com a punt de referència inicial per rastrejar la tècnica a través de fonts addicionals. És important assenyalar que aquest examen no afirma l'exhaustivitat, ni té en compte les interdependències recíproques entre els exemples presentats. No obstant això, el present article suggereix una categorització dels diversos mètodes basats en diversos factors com ara l'exactitud, la complexitat, l'estat d'exhaustivitat, els formats literaris i el públic.

Paraules clau: al-Ashraf ʿUmar; *Tabṣira*; Ibn Waḥshiyya; *al-Filāḥa al-Nabaṭiyya*; determinació del temps, lluna, calendaris.

1. Times and Calendars

A certain fascination with and also a necessity for using periodical heavenly phenomena to measure time is one of the fundamental characteristics of all human societies, which is also reflected in the rich heritage of pre-modern artefacts and manuscripts that have come down to us from Islamicate societies.[1] The apparent course of the Sun during the day and throughout the year, the apparent rotation of the fixed stars, and the phases of the Moon help in organising daily, monthly, and yearly activities, the former generally denoted as timekeeping, the latter two forming the fields of chronology and calendrics. How time was, and is, managed and perceived, is closely tied to the cultural characteristics of a society. The apparent orbit of the Sun and its position in the sky at specific times of the day organise, in Islamicate societies, the five daily prayers, an integral part of Islamic ritual norms and of significant social impact. For their determination, a variety of methods could be used, including shadow lengths, astronomical instruments, and mathematical calculations.[2] The lunar calendar based on the Moon's cycles plays a crucial role in Islamic religious practices, as it sets the rhythm of ritually significant events such as fasting in the month of *Ramaḍān* and pilgrimage in the month of *Dhū al-Ḥijja*.

1. For some noteworthy catalogues of Islamicate manuscripts and artefacts, see [no editors] 2005 (*L'age d'or des sciences arabes*); Porter, Tourkin and Vesel (eds) 2009; Maddison and Savage-Smith (eds) 1997.

2. For an introduction to timekeeping, chronology, and calendars in Islamicate societies, e.g., the following entries in *EI3*: «Astrolabes, quadrants, and calculating devices» by David A. King; «Timekeeping: socio-political and cultural aspects» by Avner Wishnitzer. Also the following entries in *EI2*: «*Ta'rīkh*» by Benno van Dalen; «*Mīḳāt*» by David A. King.

1.1 Timekeeping at Day

North of the tropic of Cancer, a terrestrial observer sees the Sun moving through the sky on a regular basis from its rising in the east through its culmination in the south to its setting in the west every day, allowing people to set times of day by tracking its route. Daily timekeeping by the Sun, i.e., using solar time, keeps track of the time based on the position of the Sun in the sky mainly by taking into consideration prominent phenomena such as end of dusk and break of dawn, sunrise, sunset, and its culmination or transit. In the pre-modern sources preserved from Islamicate societies, shadow schemes,[3] instruments, in particular sundials, but also astrolabes and quadrants,[4] data in *zīj*es,[5] and sets of tables inform about the regular motion of the Sun.[6]

1.2 Timekeeping at Night

It is understandable how much people in the past, who used to measure their time by looking into the sky during the day, wished for a similar pattern for the night sky when the Sun disappears. The fixed stars, usually learned through constellation patterns, provided a good tool to regulate the night-time. Similar to the Sun, they can be observed every night rising in the east, culminating in the south, and setting in the west. Using this apparent daily rotation to determine time at night is prevalent in many cultures, e.g., documented in the *ziqpu*-star lists from Ancient Mesopotamia, the earliest version of which are found in the MUL.APIN, an astronomical compendium of uncertain date, but composed probably before 900 B.C.[7] Another example is the nocturnal, an instrument that employs the movement of circumpolar stars with regard to the Pole Star, the first allusions to which appear in treatises

3. E.g., King 2004, vol. 1: 465–526 ; also the examples in Schmidl 2007, 256–259 (Arabic texts and German translations) and 322–325 with 572–573 and 622–625 (studies); Varisco 1994, 23–60 (Arabic text and English translations) and 88–89 (study).

4. See «*Mīḳāt*» in *EI₂* by David A. King.

5. For details, e.g., King and Samsó 2001, 21–23.

6. E.g., King 2004, vol. 1: 247–298 (Cairene corpora of timekeeping) and 356–401 (Damascene corpora of timekeeping).

7. E.g., Steele 2014, 127; Rochberg 2004, 278; Hunger and Pingree 1999, 2 and 89; Hunger and Steele 2018, 1 iii 49–I iv 9, 138–141 and 186–190.

by Gerbert of Aurillac (d. 1003) and Ramon Llull (d. 1316).[8] Pre-modern sources from Islamicate societies, besides using tables, calculations, astrolabes, and other instruments,[9] also inform of a method for timekeeping at night by means of the lunar mansions,[10] that shows, by its very nature, many similarities to the star clocks of Ancient Egypt.[11]

2. Timekeeping at Night by Means of the Moon

The fixed stars can hardly be as eye-catching in the night sky as the Moon and its phases. Although its motion was predominantly used for calendrical purposes in the Islamicate world, the daytime hours being primarily determined with respect to sunrise, sunset, and the daily path of the Sun. It is an advanced problem ascertaining a regular monthly schedule of the rapid displacement of the Moon's apparent position in the sky, which would allow timekeeping at night by means of the Moon.

The initial motivation for writing this paper was to explore the historical and mathematical background of a method for timekeeping at night by the Moon presented in chapter xxiii of al-Ashraf ʿUmar's *Kitāb al-Tabṣira fī ʿilm al-nujūm* («Book of enlightenment in the science of the stars») written in 13th-century Yemen. In this article, it serves as a primary example for a textual and contextual analysis, supplemented by an edition of the Arabic text and its English translation, to survey a number of other examples from the Islamicate sources that make use of the lunar position for timekeeping at night. The sources inspected in this

8. Forcada 1995, 208–210. For an example in books, see Apian, *Instrumentbuch*, the chapter with the title «Das Vird Tayl, Das Ander Capittl von dem Rucken». For examples of surviving instruments, see, e.g., Ward 1981, 74–76 with plate xxviii.

9. For some examples of tables and calculations in *zīj*es, see Bagheri and Hosseinzadeh (eds) 2021, 163–168; al-Bīrūnī, *al-Qānūn al-Masʿūdī*, vol. 1: 486–489; of instruments, e.g., Charette and Schmidl 2004, 116, 141 and Hill 1981.

10. For some examples, see Schmidl, al-Ashraf ʿUmar's *Tabṣira*: Chapter xxx; Samsó 2008, 122–124; Schmidl 2007, 280–305 and 326–341 (Arabic texts and German translations), 602–614 and 628–637 (studies); Schmidl 2006, 78–85; Forcada 1995, 212–213; Ibn ʿĀṣim, *Kitāb al-anwāʾ*, 1993, 117–118; Forcada 1990, 59–64; Hehmeyer 2005, 89 with n. 6, n. 7, and n. 27; Nash and Agius 2011; Nash 2015; Varisco 1994.

11. Neugebauer and Parker 1960–1969, vol. I: 1–2 and 95–115, vol. II: 1–18; Leitz 2011; Leitz 1995, esp. 61–77 and 117–140; also Neugebauer 1955, 47–49 and 50–51; Symons 2020, 24–47; Depuydt 1998; Depuydt 2011.

article provide attempts in using the nocturnal motion of the Moon to measure the passing of the time at night through approximations, observational conventions, and mathematical relations. They are chosen from different places, times, and scholarly traditions, without making any claims either to exhaustiveness or to inclusiveness and vary in their exactitude and in their demand on their audience's skills and expertise. While acknowledging the presence of diverse scholarly traditions, this paper does not seek to comprehensively examine their intersecting aspects. Consequently, the exploration of such intersections remains an open question that necessitates further investigation.

2.1 Chapter xxiii of al-Ashraf ʿUmar's Tabṣira

Chapter xxiii of the *Tabṣira* provides an approximate method to determine the rising and setting times of the Moon. This treatise was written by al-Malik al-Ashraf (Mumahhid al-Dīn) ʿUmar b. Yūsuf b. ʿUmar b. ʿAlī b. Rasūl (d. 694/1296), the third of the Rasūlid sultans, a dynasty that ruled over Yemen from the 13th to the 15th century.[12] His political efforts are, however, eclipsed by his scholarly oeuvre that he developed most probably before his ascent to the throne.[13] It comprises more than ten treatises dealing with agriculture, astronomy, astrology, astronomical instruments, animal studies, genealogy, mantic practices, and medicine.[14] He also constructed at least six astrolabes, one still preserved, and possibly other instruments.[15]

In the Oxford manuscript, one of the two copies preserved,[16] this treatise consists of 50 chapters on various topics. Its objective can be roughly summarised as

12. E.g., «Rasūlids» in EI_2 by G. Rex Smith; Mahoney and Varisco 2021.

13. al-Khazrājī (ʿAsal and Redhouse) 1906, vol. 1, 236; for the life and oeuvre of al-Ashraf ʿUmar «Ashraf» in BEA by Petra G. Schmidl; see also Schmidl 2021a, 217–219 and tabsira.hypotheses.org and the literature mentioned there.

14. Schmidl to appear; see also Schmidl 2021a, 217–219.

15. For al-Ashraf ʿUmar's astrolabe preserved in New York (The Metropolitan Museum of Art, Accession number 91.1.535a–h) King 2005, study xiva, in particular 627–632 and www.metmuseum.org/art/collection/search/444408 – last accessed 2023-07-18. For his other astrolabes and instruments King 2005, study xiva, 643–646.

16. For manuscript Oxford, Bodleian Library, Huntington 233, see Uri 1787, 196–197, no. cmv and digital.bodleian.ox.ac.uk/objects/30f0365b-326a-4552-a446-809f0adf5c5c/ – last accessed 2023-05-02. For manuscript Paris, Bibliothèque nationale de France, arabe 2601.2, see Vajda

an endeavour to collect information needed in orientation in time and space and in predicting the future, presumably also to facilitate decision-making processes.[17] Chapter xxiii is only preserved in the manuscript in Oxford, most probably from 14th-century Yemen and therefore closer to the writing of the *Tabṣira* than the copy in Paris that dates to Muḥarram 1036/March 1626.[18] Its *editio princeps* followed by an English translation is given in the appendix of this article.

Chapter xxiii provides a simple arithmetical method to delineate the night hours based on the time between the rising and setting of the Sun and the Moon based on the point at which the Moon rises, or sets, every day as an almost constant difference from its rising, or setting, times the previous day. In the pre-modern world view with its geocentric cosmos, the daily or diurnal motion of all heavenly bodies is due to the uniform revolution of the celestial sphere, the first primary motion from east to west around an axis connecting its two poles. Conventionally, it takes the celestial sphere 24 hours for a full rotation of 360° around the earth. So, a seasonal hour is defined as one-twelfth of the length of day or night. The seven planets known to pre-modern observers, including the Sun and the Moon, have their own motions in the opposite direction, from west to east, inclined to the plane of the primary motion. Therefore, determining their daily positions in the sky depends on a number of factors, requiring the use of advanced mathematical relations (see also 2.6). The approximate method in the *Tabṣira* is based on two assumptions:

(1) The Moon orbits the earth once in each lunar month, which by definition in the Hijra calendar can be *complete* with thirty days or *incomplete* with twenty-nine days.
(2) Day and night are defined by the sunrise and sunset on the local horizon, so that each day and night have 24 seasonal hours, i.e., 12 hours in the day and 12 hours in the night.

1953, 647 and gallica.bnf.fr/ark:/12148/btv1b100375751/f189.item.r=Arabe%202601 – last accessed 2023-05-02. Edition, English translation, commentary, and study of al-Ashraf ʿUmar's *Tabṣira* is in preparation by the second author. For more information, including pre-prints of the chapters investigated so far, see tabsira.hypotheses.org and the literature mentioned there.

17. E.g., Schmidl 2021a.

18. See n. 16.

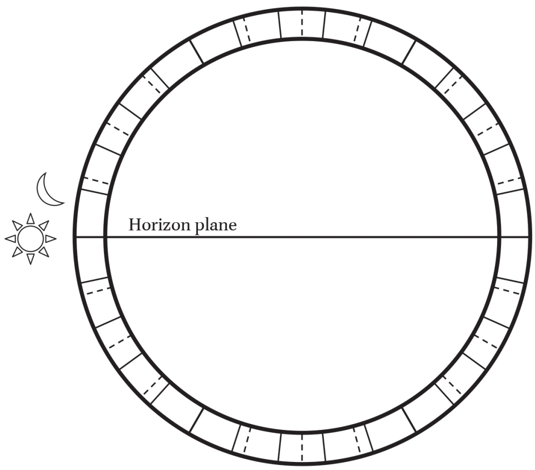

FIGURE 1. Divisions of the heavenly revolution into 24 hours (dashed lines) and 30 days (straight lines) of a complete month. Both sets of lines coincide every 5 days.

Assuming that the Moon has a uniform rotation co-axial with the primary motion of the universe, 24 hours are divided by the number of days in a lunar month in order to determine how many hours the Moon has progressed each day during its monthly cycle. The subsequent ratio will be $^{24}/_{30}$ or $^{4}/_{5}$ in a complete month of 30 days and $^{24}/_{28}$ or $^{6}/_{7}$ in an incomplete month of 29 days (see Tables 1 (a) and (b) as well as Fig. 1). Since, according to the text in chapter xxiii, it is assumed in the second case that the Moon is considered motionless on the 15th day, 28 days are counted in the calculation. By multiplying the days passed since the beginning of the month, the rising or setting times of the Moon relative to the sunset, the zero point of each night, are determined. In the *Tabṣira*, they are provided in two border- and frameless tables, for a complete and for an incomplete month, respectively, which is preceded by a recipe-like text that introduces the *rule to follow* and two examples (see Tables 1 (a) and (b) as well as the Appendix).

TABLE 1 (a): Moonrise and Moonset in the Nights of a Complete Lunar Month according to chapter xxiii of al-Ashraf ʿUmar's *Tabṣira* (h = hour[s]).

The days elapsed since the beginning of the month	Time at night when the Moon sets	The days elapsed since the beginning of the month	Time at night when the Moon rises
1	$^{4}/_{5}$ h	16	$^{4}/_{5}$ h

2	$1^3/_5$ h	17	$1^3/_5$ h
3	$2^2/_5$ h	18	$2^2/_5$ h
4	$3^1/_5$ h	19	$3^1/_5$ h
5	4 h	20	4 h
6	$4^4/_5$ h	21	$4^4/_5$ h
7	$5^3/_5$ h	22	$5^3/_5$ h
8	$6^2/_5$ h	23	$6^2/_5$ h
9	$7^1/_5$ h	24	$7^1/_5$ h
10	8 h	25	8 h
11	$8^4/_5$ h	26	$8^4/_5$ h
12	$9^3/_5$ h	27	$9^3/_5$ h
13	$10^2/_5$ h	28	$10^2/_5$ h
14	$11^1/_5$ h	29	$11^1/_5$ h
15	12 h	30	12 h

Table 1 (b): Moonrise and Moonset in the Nights of an Incomplete Lunar Month according to chapter xxiii of al-Ashraf ʿUmar's *Tabṣira* (h = hour[s])

The days elapsed since the beginning of the month	Time at night when the Moon sets	The days elapsed since the beginning of the month	Time at night when the Moon rises
1	$^6/_7$ h	16	$^6/_7$ h
2	$1^5/_7$ h	17	$1^5/_7$ h
3	$2^4/_7$ h	18	$2^4/_7$ h
4	$3^3/_7$ h	19	$3^3/_7$ h
5	$4\ ^2/_7$ h	20	$4\ ^2/_7$ h
6	$5^1/_7$ h	21	$5^1/_7$ h
7	6 h	22	6 h
8	$6^6/_7$ h	23	$6^6/_7$ h
9	$7^5/_7$ h	24	$7^5/_7$ h
10	$8^4/_7$ h	25	$8^4/_7$ h
11	$9\ ^3/_7$ h	26	$9\ ^3/_7$ h
12	$10^2/_7$ h	27	$10^2/_7$ h
13	$11^1/_7$ h	28	$11^1/_7$ h
14	12 h	29	12 h
15	at sunrise	–	–

2.1.1 Algorithmic Analysis of al-Ashraf ʿUmar’s Method

The simple formula behind the method in chapter xxiii of the *Tabṣira* is structured in a logical step-by-step guide. For the sake of clarity for modern eyes, this *rule to follow*, or recipe, can be visually explained as follows (see Fig. 2).

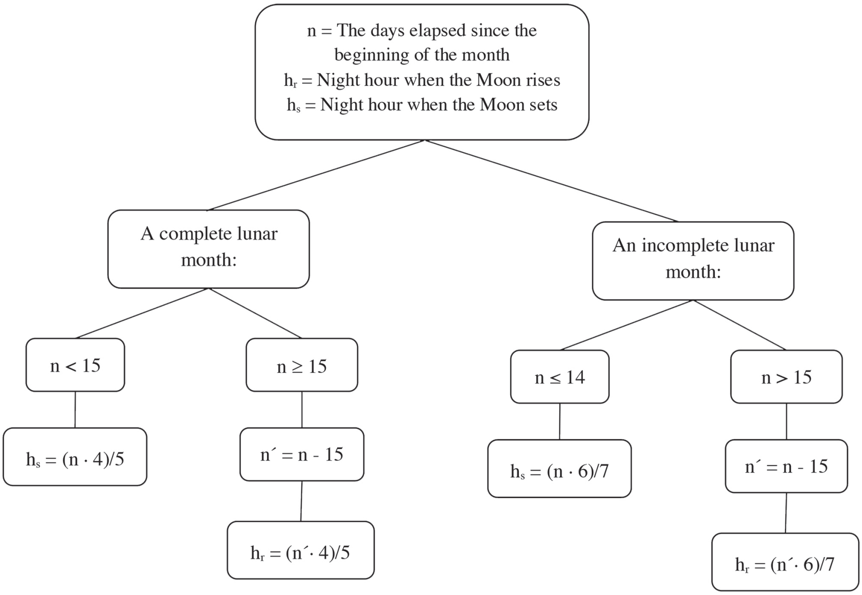

FIGURE 2. Algorithmic analysis of al-Ashraf ʿUmar’s method (Note that the purpose of this diagram is only to display the mathematical procedure through visual aids without adapting standard symbols used in modern flowcharts).

As with most of the other chapters in the *Tabṣira*, al-Ashraf ʿUmar does not mention his sources in chapter xxiii. The method he presents is, however, not unique, again similar to many other chapters of the *Tabṣira*, where the author introduces well-known topics without referring to his sources.[19] It occurs in a number of pre- and early modern texts written in the Islamicate societies.

19. E.g., in chapter vi al-Ashraf ʿUmar deals with the terms, a common subject discussed in the astrological introductory literature (see Schmidl, al-Ashraf ʿUmar’s *Tabṣira*: Chapter vi); in chapter xii he introduces metaphors describing a planet being in one of the twelve astrological houses that

2.2 *Examples in the* Anwāʾ *Literature*

Examples found in the *anwāʾ* literature bear strong resemblance to the method in chapter xxiii of al-Ashraf ʿUmar's *Tabṣira*. Although they are all derived from the same formula, the presentation of the methods differs. Some authors limit themselves to giving a recipe, mostly how to use the ratio $^6/_7$, and to providing a few individual examples without mentioning the values for all days of a month,[20] Others present the position of the Moon, day by day.[21] Judging by the available editions of these works, none of these examples arranges its data in a tabular form similar to the tables in chapter xxiii of the *Tabṣira*; its line-by-line structure also stands unique among them. The dominant form of presentation is continuous text without any visual layout except for calligraphic markings.

Another point of difference concerns mentions of the method's impreciseness. While some works on *anwāʾ*, similar to the *Tabṣira*, remain silent on the approximate nature of this method, others, such as the text by Abū Isḥāq Ibrāhīm b. al-Ajdābī (d. 650/1251),[22] even provide reasons for it:

> ويغيب الهلال أوّل ليلة من الشهر لستة أسباع ساعة تمضي من الليل . ثمّ يتأخّر مغيبه كلّ ليلة مقدار ستّة أسباع ساعة حتّى يكون مغيبه في الليلة السابعة نصف الليل ، وفي ليلة أربعة عشر مع طلوع الشمس . وقد يتقدّم ذلك أحياناً ويتأخّر على قدر سرعة القمر وإبطائه ، وتمام الشهر ونقصانه . ثمّ يتأخّر طلوعه ليلة خمسة عشر مقدار ستّة أسباع ساعة ويزيد تأخّره مثل ذلك حتّى يكون طلوعه ليلة إحدى وعشرين نصف الليل .

> The crescent sets on the first night of the month when six sevenths of an hour have passed since the night. Then, its setting is delayed every night by six sevenths of an hour until it sets on the seventh night at midnight, and on the fourteenth night at sunrise. This may sometimes precede and delay depending on the speed of the Moon as

are most probably taken from the Ikhwān al-Ṣafāʾ's epistle *On Astronomia* without saying so (see Schmidl, al-Ashraf ʿUmar's *Tabṣira*: Chapter xii).

20. E.g., Ibn Qutayba, *Kitāb al-Anwāʾ*, 129–130; ʿAbdallāh al-Thaqafī, *al-Anwāʾ wa-l-azmina*, 29; Ibn al-Ajdābī, *al-Azmina wa-l-anwāʾ*, 88.

21. E.g., Abū ʿAlī al-Marzūqī, *Kitāb al-Azmina wa-l-amkina*, 485, who does not detail the second half of the month and instead explains that the values in the two halves of the month are symmetrical.

22. Arabic text according to the edition in Ibn al-Ajdābī, *al-Azmina wa-l-anwāʾ*, 88; English translation by the first author.