SOME ASTRONOMICAL OBSERVATIONS FROM
THIRTEENTH-CENTURY EGYPT

DAVID A. KING, New York University, and
OWEN GINGERICH, Harvard-Smithsonian Center for Astrophysics

1. Introduction

In this study we present a list of thirteen planetary conjunctions observed in
medieval Egypt. Such lists are rare in the medieval Islamic sources, and indeed
the one presented here is only the second to come to the attention of historians.
The first was the list of over one hundred observations recorded by the tenth-
century Egyptian astronomer Ibn Yûnus, published by the French orientalist
Caussin de Perceval in 1804.¹

The list that we present and discuss here was located by King in 1974 in a
manuscript of a medieval Arabic astronomical handbook preserved in the
Municipal Library in Alexandria and numbered 5577C. In 1975 an earlier copy
of the same work was located in the British Library in London, numbered
Or. 9116. This work belongs to the category of Islamic astronomical handbooks
known in medieval Arabic as zijes, of which almost 200 were compiled by
Muslim astronomers during the millenium following the rise of Islamic
astronomy in the eighth century.² The Islamic zijes contain extensive tables
and instructions for solving all the standard problems confronting the medieval
astronomer, such as the determination of planetary and stellar positions, the
computation of conjunctions and eclipses, and problems relating to time-
keeping. The zij preserved in Alexandria and London is entitled Tayṣir al-matālib
fi tasyr al-kawâkib, “The simplification of problems in finding the motions of
celestial bodies”, and was compiled by the thirteenth-century Yemeni astronomer
Muḥammad ibn Abī Bakr al-Kawâshi.³ The Alexandria manuscript was copied
in Sanaa in the year 1730. The London manuscript, which lacks the title folio
and the name of the author, can be dated to the fourteenth or fifteenth century.

Although al-Kawâshi worked in the Yemen and prepared his planetary
tables for the longitude of Taiz, his zij is based largely on earlier Egyptian and
Iraqi material. The Yemen was an important centre of astronomy in the Middle
Ages, particularly in the thirteenth century, and the numerous extant Yemeni
astronomical works are of interest because some of them preserve material
from earlier Iraqi, Egyptian, and North African sources that are no longer
extant in their original form.⁴ al-Kawâshi’s zij, like several other of these
Yemeni sources, merits detailed study.

The fifth chapter of the introduction to al-Kawâshi’s tables deals with
planetary mean motions and begins with the list of the observations that the
author claims to have made in order to derive the parameters on which his
planetary tables are based. It seems probable that al-Kawâshi made the obser-
vations himself, although he is not mentioned in any known contemporary or
later Egyptian sources.⁵ The observations were made either in Quṣ in the Nile
Valley or in Alexandria, both flourishing cities in medieval times, but no other
scientific activity of consequence in either locality is known from this period.
al-Kawâshi gives no indication that he actually used these observations either
to check his planetary parameters or to derive new parameters. The same holds for Ibn Yunus and his observation reports: his new parameters are introduced without explanation. The only new parameter which al-Kawāshi presents is a value of the obliquity of the ecliptic that he states to have derived himself, namely, 23;32,50°. This value is not attested in any other Islamic work that is currently known.

Our present purpose is simply to present the list of observations as it appears in the two manuscripts, giving the Arabic text (Section 2), a translation (Section 3), and a commentary (Section 4) in which we investigate each of the observation accounts using modern tables of planetary positions in medieval times. The numbering of the observations is our addition to the text.

2. The Arabic Text

The text of al-Kawāshi's observation list occurs on fols. 19v–20r of the London manuscript (A) and fols. 11r–11v of the Alexandria manuscript (B). It reads as follows:

قطعة من تيسير المطلوب لمحمد بن أبي بكر الكواشي

أ : مخطوطه المكتبة البريطانية ٩١١٦ ، ق ١٩ ظ - ٢٠ و

ب : مخطوطه الاستودير المكتبة البلدية ٥٧٧ ، ق ١١ و - ١٠ ظ

الباب الخامسة: ذكرنا شاهدنا بالحر من قران الكوكب بعضهما

لبعض (١) قرآن القمر عطارد وكسفه بعدن قوس مكمف ف نحو نصف

ساعة وًذلك في الساعة الثانية من ليلة الثلاثة، ثم المحرم سنة ٦٧٢ ٢

وقران القمر زحل في أول الثلاثاء من ليلة الأحد عشر المحرم سنة ٦٧٦ ٦

وكان بينهما في العرض ١٠ نحو شهري واحد (٢) وقارنان الزهرة المشرية بكرة

شهري يوم الاثنين تام عشر المحرم سنة ٦٧٦ و بينهما في العرض ١٠٠

شخبر واحد تقريرا (٣) وقارنان القمر المشرية وقت خاصة ليلة السبت

حاسم شهر شعبان سنة ٦٧٧ ٥ وقارن المشرية قلب الأسد بكرة نهار

يوم الخميس التام والعشرين من جمادى الأولى سنة ٦٧٨ وقد تقدمه

الوشرية بعد رفع ربيع واحدة تقريرا (٤) وقارنان القمر المشرية في أول

الثلاثة من ليلة السبت سابع عشر رمضان سنة ٦٧٨ وهما على خط نصف
Astronomical Observations from Egypt

3. Translation

"Chapter 5 on the planetary conjunctions which we observed.

(1) The Moon was in conjunction with Mercury and occulted it at the town of Qus. [The planet] remained occulted for about half an hour. This was during the second hour of the night of Tuesday, Muḥarram 2, in the year 672 [Hijra].

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(2) The Moon was in conjunction with Saturn at the beginning of the third [hour] of the night of Sunday, Muḥarram 10, in the year 676. There was about one span latitude difference between them.

(3) Venus was in conjunction with Jupiter early in the morning of Monday, Muḥarram 18, in the year 676. There was an estimated latitude difference of about one span between them.

(4) The Moon was in conjunction with Jupiter at the time of the night [prayer] on the night of Saturday, Shawwāl 15, in the year 677.

(5) Jupiter was in conjunction with Regulus early in the morning of Thursday, Jumādā I 28, in the year 678. Jupiter had an estimated latitude excess of one digit.

(6) The Moon was in conjunction with Jupiter at the beginning of the third [hour] of the night of Saturday, Ramaḍān 17, in the year 678. They were both on the meridian and their estimated latitude difference was two digits or [a little] less.

(7) Mercury was in conjunction with Jupiter on the morning of Monday, Jumādā I 14[?], in the year 679. There was an estimated latitude difference of one digit between them.

(8) Venus was in conjunction with Saturn early in the morning of Monday, Shawwāl 15, in the year 680. Saturn was ahead of [Venus] in longitude by about one span and the next night [i.e., early the next morning] Venus was ahead of [Saturn] by about one span.

(9) Mars was in conjunction with Regulus early in the morning of Tuesday, Rabi‘ I 9, in the year 681. It was very close to [the star].

(10) The Moon occulted Venus on the night of Saturday, Muḥarram 4, in the year 682. The beginning [of the occultation] was at the end of the second hour of that night and [Venus] remained covered until the middle of the fourth [hour] of the night at Alexandria.

(11) Mars was in conjunction with Regulus on Tuesday, Rabi‘ I 7, in the year 683 [MS B has 682!]. The estimated [time of the] conjunction was between the midday and afternoon [prayers].

(12) Venus was in conjunction with Mars early in the morning of Sunday, Jumādā II 7, in the year 683.

(13) The Moon was in conjunction with Saturn early in the morning of Friday, Rabi‘ II 15, in the year 683. The Moon was an estimated one-third of a degree ahead of [Saturn] in longitude, and there was about two degrees or [a little] less latitude difference between them.”

4. Commentary

The following remarks are based on an examination of the reported observations. For each observation we have converted the dates to the Christian calendar and ascertained the details of the conjunctions or occultations.

The Hijra dates given in medieval Arabic astronomical texts may be either according to the civil or astronomical reckoning. The epoch of the Islamic Hijra calendar according to the civil reckoning is taken as Friday, 16 July 622 A.D. This was the evening of the first visibility of the lunar crescent marking the first day of the pagan Arab year in which the Prophet Muḥammad emigrated from Mecca to Medina (in Arabic, al-hijra, literally, “the breaking of ties”).
According to the astronomical reckoning the epoch is the preceding day when the true conjunction of the Sun and Moon occurred. In medieval Arabic astronomical texts both systems are used, and we need to know the corresponding day of the week in order to convert to another calendar. Modern tables display the dates in the Christian calendar corresponding to the beginning of each Hijra month from the seventh century to the present, and we have relied on these. The reader should bear in mind that the Islamic day begins at sunset, so that, for example, the Arabic laylat al-ithnayn, literally “the night of Monday”, means “the night preceding Monday morning”. Also, al-Kawāshi uses seasonal hours representing twelfth divisions of the length of daytime or night-time, and hence varying throughout the year and depending on the local latitude. He expresses some of the times of day and night in terms of the times of prayer, which in Islam are astronomically defined.

To check these medieval planetary observations we have used a computer program originally written by P. Huber at the Eidgenössische Technische Hochschule in Zurich (and now of Harvard) and similar to that used for the tables of B. Tuckerman. We have added the coding to give topocentric positions of the Moon. For the star Regulus we have used a position computed from P. V. Neugebauer’s Sterntafeln.

The Arabic terms used for small angular distances on the celestial sphere, asbāb, “digit” (that is, finger-breadth), and shibr, “span”, correspond to apparent elongations of about $\frac{1}{12}$ and $\frac{1}{3}$, respectively.

All of the observations are rather crudely described, and there is no need to suppose that they are anything other than naked-eye observations. Only in observations 1 and 10 are the locations Qus and Alexandria specifically mentioned. It may be that observations 1 to 9 were made in Qus, and observations 10 to 13 were made in Alexandria, wa-ilāhu arlam, “but God knows better”; in any event, it makes scarcely any difference for the rather low precision of the given observations. Fortunately the most interesting records for a modern astronomer are observations 1 and 10. The geographical coordinates of Qus and Alexandria are as follows:

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qus</td>
<td>25°55'</td>
</tr>
<tr>
<td>Alexandria</td>
<td>31°12'</td>
</tr>
</tbody>
</table>

The time equivalent of the longitude, together with the equation of time for the day in question, allows the apparent time of the observations to be converted into universal time (UT), which always begins at Greenwich midnight; for our purposes we are not distinguishing universal and ephemeris times. For times of sunset and sunrise we have used the tables in The American ephemeris and nautical almanac.

(1) Muharram 2, 672 Hijra in the astronomical calendar corresponds to Tuesday, 18 July 1273. The occultation of Mercury thus took place on the evening of Monday, 17 July 1273. Since the solar longitude was about 121°8 on that evening, sunset occurred at about 6h40m after midday (= 16h36m UT) and one seasonal night hour equals about 55m. Our calculations show that the occultation began almost precisely one seasonal night hour after sunset, and that the moonset half an hour later prevented observations of the conclusion of the phenomenon.
(2) Muḥarram 10, 676 Hijra in the civil calendar corresponds to Sunday, 13 June 1277. According to our calculations, the conjunction between Saturn and the Moon took place on the evening of Saturday, 12 June 1277. Since the solar longitude was about 88°-5 on that evening, sunset occurred at about 6h50m after midday (= 16h42m UT) and one seasonal night hour at Qus corresponded to about 52m. The closest approach took place at 19h 17m UT, that is, at the end of the third seasonal night hour after sunset.

(3) Muḥarram 18, 672 Hijra in the civil calendar corresponds to Monday, 21 June 1277. The close approach of Venus and Jupiter was observed early in the morning whereas the true conjunction in longitude actually followed in the afternoon of 21 June when Venus was not visible. The latitude difference was very close to 3° at dawn on 21 June.

(4) Sha'bān 15, 677 Hijra in the astronomical calendar corresponds to Saturday, 31 December 1278. The conjunction took place on the evening of Saturday, that is, on the preceding Friday night, and was not particularly impressive because the Moon was over four degrees north of Jupiter. With such a distance the precise time of close approach would have been difficult to measure. Medieval Egyptian astronomers would have calculated nightfall (and the time of prayer) for a solar depression of 17°, which matches the conjunction with more than enough precision.

(5) Jumādā I 28, 678 Hijra in the astronomical calendar corresponds to Thursday, 5 October 1279. The positions of Jupiter and Regulus on that day were:

<table>
<thead>
<tr>
<th></th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jupiter</td>
<td>139°-9</td>
<td>+0°-8</td>
</tr>
<tr>
<td>Regulus</td>
<td>139°-9</td>
<td>+0°-2</td>
</tr>
</tbody>
</table>

This latitude difference is closer to a span than the digit mentioned in the text.

(6) Ramaḍān 17, 678 Hijra in the astronomical calendar corresponds to Saturday, 20 January 1280. The conjunction is stated to have taken place with the Moon on the meridian at the beginning of the third hour of the "night of Saturday", that is, on Friday, 19 January 1280. Since the Moon was a day past full, it could not come to the meridian until after midnight, so the details of the report are faulty. The solar longitude on that date was about 307°, sunset came at 5h35m after midday, and the seasonal night hour was 64m. Thus the third hour of the night began at Qus about 2h8m after sunset, or at 15h37m UT. The conjunction actually took place in the fifth seasonal hour after sunset, with the Moon 2°-5 above Jupiter (rather than the specified two digits) and our calculations show that by the time the Moon was on the meridian, it had advanced a degree in longitude beyond Jupiter.

(7) This report is slightly garbled. MS A has Jumādā I 13 with an additional note in a different hand that 14 is better. MS B has simply Jumādā I 14. The morning of Jumādā I 14, 679 Hijra, in the civil calendar corresponds to Thursday, 11 September 1280. According to our calculations the conjunction in longitude actually took place before Mercury and Jupiter were visible in the eastern dawn on the morning of 11 September 1280; the latitude difference when the planets became visible just before dawn was about 3°, that is, more than one span rather than the one digit stated in the text.
(8) Shawwāl 15, 680 Hijra in the astronomical calendar corresponds to Monday, 26 January 1282. According to our calculations for that morning, Saturn was ahead of Venus in longitude by about \( \frac{3}{8} ^\circ \) (i.e., a little more than a span) and the following morning Venus was ahead of Saturn by just under \( \frac{1}{4} ^\circ \) (i.e., about a span). Their latitude difference was slightly greater than \( 1 ^\circ \). We find:

<table>
<thead>
<tr>
<th>Date</th>
<th>Mercury</th>
<th>Saturn</th>
</tr>
</thead>
<tbody>
<tr>
<td>1282 Jan. 26·2 (UT)</td>
<td>269°·53</td>
<td>+2°·2</td>
</tr>
<tr>
<td></td>
<td>270°·20</td>
<td>0°·8</td>
</tr>
<tr>
<td>1282 Jan. 27·2</td>
<td>270°·68</td>
<td>2°·1</td>
</tr>
<tr>
<td></td>
<td>270°·29</td>
<td>0°·8</td>
</tr>
</tbody>
</table>

The date as given in the translation thus seems secure. In MS A the day of the week is given as Tuesday, corrected to Monday, and the day of the month is given as 16, corrected to 15.

(9) Rabī‘ I 9, 681 Hijra in the astronomical calendar corresponds to Tuesday, 16 June 1282. The text indicates only that the conjunction is close, and we find Regulus to be about a degree south of Mars:

<table>
<thead>
<tr>
<th>Body</th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mars</td>
<td>139°·8</td>
<td>+1°·2</td>
</tr>
<tr>
<td>Regulus</td>
<td>139°·9</td>
<td>+0°·2</td>
</tr>
</tbody>
</table>

(10) Muḥarram 4, 682 Hijra in the astronomical calendar corresponds to Saturday, 3 April 1283. The occultation took place on Friday, 2 April 1283. Since the solar longitude was about 20°, the second seasonal hour of the night at Alexandria ended about 1h55m after sunset or about 6h20m + 1h55m = 20h15m after astronomical midday, and the middle of the fourth hour of the night was about 3h15m after sunset or about 6h20m + 3h15m = 21h40m after midday. Although the text thus indicates an approximate duration of 1h20m, an occultation of Venus can last only about an hour unless the planet is moving rapidly with the Moon. Our calculations, with an accuracy of about five minutes, show that the occultation began at 19h42m in Alexandria and ended at 20h42m, with the Moon then at an altitude of 16°. It is interesting to note that the reported times agree somewhat better for Qus than for Alexandria.

(11) Rabī‘ I 7, 683 Hijra in the astronomical calendar corresponds to Tuesday, 23 May 1284. Our calculations show that the conjunction actually took place around midday (for longitudes in Egypt) on 22 May rather than 23 May. Because the latitude difference was about 1\( \frac{1}{2} ^\circ \), it would have been somewhat difficult to record by naked eye on which evening the approach was closest; since the reported event took place in the daytime, the estimated time of the conjunction was derived by interpolation or possibly by computation. Computation with the Toledan Tables, for example, would have given the same date we find provided a good position of Regulus was available. For May 22·4 (UT) we find:

<table>
<thead>
<tr>
<th>Body</th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mars</td>
<td>139°·9</td>
<td>+1°·37</td>
</tr>
<tr>
<td>Regulus</td>
<td>139°·9</td>
<td>+0°·2</td>
</tr>
</tbody>
</table>

(12) Jumādā‘ II 7, 683 Hijra in the astronomical calendar corresponds to Sunday, 20 August 1284. According to our calculations the true conjunction in longitude took place somewhat earlier on the previous evening (19 August)
before Venus and Mars had risen, but the two planets were still very close when they became visible on the Sunday morning. Their latitude difference was about $\frac{1}{3}^\circ$.

(13) Rabī' II 15, 683 Hijra in the astronomical calendar corresponds to Friday, 30 June 1284. According to our calculations, Saturn and the Moon came into conjunction that morning following sunrise; in other words, the phenomenon was terminated by dawn. At about dawn (June 30·11 UT) the situation was as follows:

<table>
<thead>
<tr>
<th></th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moon</td>
<td>292°·12</td>
<td>+0°·41</td>
</tr>
<tr>
<td>Saturn</td>
<td>293°·85</td>
<td>−0°·27</td>
</tr>
</tbody>
</table>

In other words, the separation is about as described in the text except that the components of longitude and latitude are mixed—there is no way to get the specified $2^\circ$ in latitude. The event was quite similar at Qus.

Acknowledgements

The research on medieval Islamic astronomy conducted at the American Research Center in Egypt during the period 1972–79 was supported mainly by the Smithsonian Institution and the National Science Foundation. It is a pleasure to record our gratitude to the Municipal Library in Alexandria and the British Library in London for providing microfilms of manuscripts in their collections.

REFERENCES

3. More information on the author and his zij is given in D. A. King, Mathematical astronomy in medieval Yemen (Publications of the American Research Center in Egypt; Malibu, California, 1982), Section II.7.
4. Ibid., for details of this tradition.
6. For further details see W. Hartner, “Zamán” in The encyclopaedia of Islam (1st ed., Leiden, 1913–34), reprinted (German version only) in idem, Oriens–Occidens (Hildesheim, 1968), 260–3.
7. Wüstenfeld-Mahler’sche Vergleichungstabelle zur Muslimischen und Iranischen Zeitrechnung... (Wiesbaden, 1961) and Robert Schramm, Kalendarigraphische und Chronologische Tafeln (Leipzig, 1908).
8. For details see D. A. King, “Ibn Yûnûs’ Very useful tables for reckoning time by the Sun”, Archive for history of exact sciences, x (1973), 343–94, pp. 345–7. Sunset, daybreak, nightfall, and other times of religious significance can be calculated for any terrestrial latitude and solar longitude by using modern computer-generated tables similar to those used by medieval Muslim astronomers (ibid., 353).
11. These terms and others are used also by Ibn Yûnûs but are nowhere precisely defined. See E. W. Lane, An Arabic–English lexicon (London, 1863; reprinted Beirut, 1968), sub aqbaʿ, shibir, and rumh.