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## Vorwort der Herausgeber

Zu allererst möchten wir uns bei den Leserinnen und Lesern für das verspätete Erscheinen des 36. Bandes entschuldigen. Die Corona-Pandemie hat in verschiedener Weise das Verfassen, Redigieren, Überarbeiten und Layouten der Aufsätze behindert. Von M. Ebeid, der einer Corona-Infektion erlag, müssen wir zu unserer großen Betroffenheit Abschied nehmen.

Mit Band 36 wechselt Enchoria vom Offset- zum Digitaldruck. Wir denken, daß damit auch in Zukunft eine bezahlbare hohe Abbildungsqualität sichergestellt ist.

Auch auf eine Neuerung bei der Demotistischen Literaturübersicht möchten wir hinweisen: Der Harrassowitz Verlag stellt sie von jetzt an unter https://www.harrassowitzverlag.de/zeitschrift_386.ahtml online. So bleiben die Daten langfristig digital verfügbar, und die Benutzer der DL können den angegebenen Links ohne mühsames Abtippen der Internetadressen folgen. Wir hoffen, daß die DL auf diese Weise der Demotistik und darüber hinaus den Altertumswissenschaften generell noch mehr Nutzen bringen kann.

Eine weitere gute Nachricht erfüllt uns mit besonderer Freude: 2021, wenn die meisten den hiermit vorgelegten 36. Band erstmals in Händen halten, wird die Zeitschrift 50 Jahre alt. Dieses Jubiläum ist für uns Anlaß zum Dank dafür, daß Enchoria schon so lange in einer thematischen Ausrichtung und formalen Aufteilung existiert, die seit dem Erscheinen des ersten Bandes 1971 im wesentlichen unverändert geblieben sind, da sie sich bewährt haben und in der Fachwelt positiv aufgenommen worden sind. Wir danken dem Verlag für den Platz in seinem Programm, die Betreuung und stets gute Verarbeitungsund Druckqualität, besonders auch bei den Tafelabbildungen. All denen, die sich um die Layouterstellung gekümmert haben, danken wir ebenfalls für ihre Mühen. Schließlich sei den Autorinnen und Autoren sowie den Leserinnen und Lesern für ihre Treue und Geduld über die Jahre gedankt. Zum „Geburtstag" wünschen wir uns, daß weiterhin viele Beiträge an Enchoria gesandt werden, damit unsere Zeitschrift auch in Zukunft gut gedeihe!

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# Astronomica Montserratensia I <br> A Demotic monthly almanac with synodic phenomena <br> (P. Monts.Roca inv. 314) ${ }^{1}$ 

(Plates 1-3)
P. Monts.Roca inv. 314 contains the only Demotic monthly almanac attested so far. It preserves a section of two columns that record the movement of the planets for two consecutive years (Venus and a hint of Mercury in column 1, and Jupiter and Mars in column 2), indicating month, day, zodiac sign, longitude in degrees and minutes, and synodic phenomena if present. From the analysis of the information recorded I propose a dating of the data to the years 71-73 CE. The table contains the first evidence for the designation of synodic phenomena in Demotic, and allows for the proposal of an interpretation of the origin of the sign for first and last visibility used in Greek papyri. It also contains evidence for a secondary use of the sign for zero, attested in Babylonian astronomical texts as well. P. Monts. Roca inv. 314 thus provides further evidence for the transmission of astronomical knowledge from Mesopotamia to the Greek world through the mediation of Egypt.

[^0]
## 1. Description

P. Monts.Roca inv. 314 is part of the Roca-Puig papyrological collection housed at the Abbey of Montserrat, Barcelona (Spain). The papyrus is preserved in seven fragments of different size and shape, ${ }^{2}$ of which fragments $1,2,5,6$ and 7 join. The color of the papyrus is light brown, and none of the fragments preserve any original margins. The script is small and is written using a pen, with ink of an intense black color. The upper and middle sections of Fr. $1+2+5+6+7$ have suffered severe abrasion, which makes the text on them illegible. The verso is blank except on Frs. 1 and 4, which show at least two lines of extant text on their top part (cf. Fig. 6). The traces on the second line of Fr. 1 verso could be read as the number 25. In this case, the closed loop of the 5 -sign, characteristic of the scribe of the verso, could indicate that both sides of the papyrus were written by the same scribe. The traces at the end of the first line of this fragment may be read as the personal name $P 3-d i-p 3-h r d .{ }^{3}$ The rest of the surface displays a series of traces that seem to be just darker fibers. The recto of the main fragment, Fr. $1+2+5+6+7$, contains the remains of two columns. The text is not framed by any guidelines, except for a clearly preserved horizontal line in Fr. $1+2+5+6+7$ col. 1, between lines $x+19$ and $x+20$, and the traces of a horizontal line between col. $2, \mathrm{x}+14$ and $\mathrm{x}+15$.

The text presented here is a planetary table of the type designated as a monthly almanac, ${ }^{4}$ since it registers the movement of the planets indicating their positions along the ecliptic on each month of the year. Each entry occupies a line, which has the following structure: month, day, zodiac sign, longitude, and indication of a particular event in the synodic cycle of the planet, if present.

[^1]
## 2. Edition of the text

Fragment $1+2+5+6+7$
Column 1


## Column 2



$$
\begin{aligned}
]^{\prime} 21^{\prime} & \Omega{ }^{`} m^{\prime}[ \\
& ]^{\prime} m^{\prime}[
\end{aligned}
$$

## Fragment 3

$\mathrm{x}+1$
] 'H’ $\star$
12 . [
] $\quad-0[.]^{「} 2^{\prime}[$

Fragment 4
$\mathrm{x}+1 \quad$.
. [
].
. [
1 ${ }^{\circ} \not+$ *

- 0 [
1'H’
- '0’ [


## 3. Translation

Fragment $1+2+5+6+7$
Column 1
[last entry for previous planet]
[Title: Venus]

|  | [1 | Leo |  |
| :---: | :---: | :---: | :---: |
|  | [2 | Virgo] | - ${ }^{\circ} 0^{\prime}[$ ] 9 |
| $\mathrm{x}+5$ | [3 | ] ${ }^{\text {Libra }}$ | - 0 [ ] ${ }^{\circ} 5^{\prime}$ |
|  | [4 | ] Scorpio | - ${ }^{\circ}{ }^{\prime}$ [ ] 8 |
|  | [ | ] Sagittarius | - 052 |
|  | [5 | ] Capricorn | - 10 |
|  | [6 | ] Aquarius' | - 012 |
| $\mathrm{x}+10$ | [7 | ] Pisces' | 018 |


|  | [8 | Aries] |  |
| :---: | :---: | :---: | :---: |
|  | [ | morning last] |  |
|  | [9 | Taurus] |  |
|  | [ | Gemini] |  |
| $\mathrm{x}+15$ | [10 | Cancer] |  |
|  | [ | ] 'evening first' | - 4056 |
|  | [11 | ] Leo | - 050 |
|  | [12 | ] Virgo | - 026 |
|  | [epag. ] day 3 | Libra | $-{ }^{\prime} 10{ }^{\prime} 5$ |
| $\mathrm{x}+20$ | [Title: Mercury] |  |  |
|  | [1 |  | ] $70 .[]$ |

## Column 2

[Title: Jupiter]

|  | [1 |  | Libra] |  |
| :---: | :---: | :---: | :---: | :---: |
|  | '2' |  | 'Libra' | [last visibility |
|  | day ' 26 ' |  | ${ }^{2} 20{ }^{\prime} 050[+\mathrm{x}$ | first visibility] |
| $\mathrm{x}+5$ | 3 | day 1 | Libra | ${ }^{\prime} 20{ }^{\prime}$ [+x |
|  | 4 | day 6 | [Scorpio] |  |
|  | 5 | day 1 | Scorpio [ |  |
|  | 6 | day 1 | Scorpio | - $6^{\circ} 0$. ${ }^{\text {[ }}$ |
|  | 7 | day 1 | Scorpio | 70 [5] $7^{\prime}$ ' 'first' station |
| $\mathrm{x}+10$ | 8 | day 28 | Scorpio | - '2 0 ${ }^{\text { }} 1^{\text {'6 acronychal }}$ |
|  | 9 | 'day 10+x | Libra' | 「.. 52 |
|  | 10 | 'day 29 | Libra | . . . . second station ${ }^{\text {² }}$ |
|  | 11 | ${ }^{\circ}$. | Libra | . . . ${ }^{\circ}{ }^{\text {r }}$. |
|  | ${ }^{\prime} 12$ | . | ${ }^{\text {'Scorpio }}$ |  |
| $\mathrm{x}+15$ | ${ }^{\text {'Title: Mars }}{ }^{\text { }}$ |  |  |  |
|  | ${ }^{\prime} 1$ | day '15 | Leo |  |


|  | 2 | 'day 2 '5 | Leo | - 21021 first visibility ${ }^{\text { }}$ |
| :---: | :---: | :---: | :---: | :---: |
|  | 3 | 'day $13{ }^{\prime}$ | Virgo' | - 0 '.. ${ }^{\text { }}$ |
|  | 4 | day 1 | Virgo | $8^{\circ} 0^{\prime}$ [ |
| $\mathrm{x}+20$ | 5 | day 1 | Virgo' | 19 [ |
|  | 6 | day 3 | Libra | - [ |
|  |  | ] '.1 ${ }^{1}$ first station ${ }^{\mathrm{r}}{ }^{-1}$ [ |  |  |
|  |  | ] '21`Libra`Virgo' [ |  |  |
|  |  | ] 'Virgo' [ |  |  |

## Fragment 3

```
\(\mathrm{x}+1 \quad\) ] 'Gemini` 12 . [
    ] \(-0[.]^{\text {r }} 2^{\text { }}[\)
```

Fragment 4
x+1 ]. . [
]. . [
]'Pisces' $\quad$ - 0 [
]'Pisces’ - '0’ [

## 4. Textual notes

Fragment $1+2+5+6+7$
1, $\mathbf{x + 4}$ : For the reconstruction of the months cf. Commentary infra.
In the transliteration I have used a hyphen to indicate the sign that looks like the preposition $n$. This sign appears at the beginning of most of the indications of longitude, but not in a consistent way. It seems to be simply a way of separating the data of the longitude from the zodiac sign. A similar sign with the same function appears in P. Carlsberg $638^{5}$

[^2]separating the zodiac sign from the longitude, although in that case it resembles more a dot than a hyphen. ${ }^{6}$

The longitude on this line has the clear remains of the number 9 in the minutes position, with the diagonal tail of the sign extending towards the line below. This sign is probably preceded by another sign for the tens place in the minutes position. The remaining traces after the hyphen fit those for the sign for zero, and the movement of the planet in the following columns, which appears to be one sign each month (ca. 30 degrees), confirms this reading. This also allows the reconstruction of the missing zodiac sign as Virgo (cf. next note). For the sign for zero cf. section 7 infra and Table 4.
$\mathbf{1 , x + 5 : ~ T h e ~ z o d i a c ~ s i g n ~ i s ~ b a r e l y ~ v i s i b l e , ~ b u t ~ t h e ~ r e m a i n i n g ~ t r a c e s , ~ t h e ~ m o v e m e n t ~ o f ~ t h e ~}$ planet of a complete zodiac sign each month, and the presence of Scorpio in the next line, indicate that the sign has to be Libra. The shape of Libra in this papyrus is not like any of the symbols used in other published Demotic astronomical papyri (cf. Fr. $1+2+5+6+7$, col. $1, \mathrm{x}+19$; and col. $2, \mathrm{x}+5, \mathrm{x}+21, \mathrm{x}+24$. Less clearly preserved in col. $2, \mathrm{x}+11$ and $\mathrm{x}+12$ ). P . Carlsberg 638, which has a very similar (probably identical) hand and the same shapes for the zodiac signs, unfortunately does not preserve any entries with a position in Libra ${ }^{7}$.
The longitude has 0 in the position for degrees, and a two digit number ending in 5 for the minutes.
$\mathbf{1}, \mathbf{x}+\mathbf{6}$ : The longitude seems to start with 0 for the degrees position, although the lower $t$ like trace of the sign seems to be displaced to the right. The section of papyrus that preserves the top part seems to be slightly moved towards the left. As for the minutes position, traces of a horizontal line are preserved, which might belong to a number 8. The space available allows the presence of another number in the tens, as in line $\mathrm{x}+10$ below in this same column.
$\mathbf{1 ,} \mathbf{x}+\mathbf{7}$ : The zodiac sign is only partially preserved in a trace that extends under the stardeterminative. The sequence of planetary positions in this section indicates that it has to be Sagittarius. The trace fits the arrow shape of the sign in other Demotic astronomical papyri. ${ }^{8}$
1, $\mathbf{x + 9}$ : The sign for Aquarius has a little tick on its upper left part, the meaning of which is unknown to me. This tick also appears on the upper left part of Pisces on col. 1, x+10,

[^3]and of Virgo on col. $1, x+18$, and col. $2, x+18$ and $x+20$ (perhaps on col. $2, x+24$ supralinear), but not on col. 2, $x+19$. It is not present in P. Carlsberg 638. The sign for Virgo in P. Berlin 8279 and in the Stobart Tablets is just the figure of the seated woman, without any ticks. ${ }^{9}$ Although the tick might reflect how the scribe of P. Monts.Roca inv. 314 writes the sign for Aquarius, Pisces, and Virgo, having been left out by accident in col. 2, $x+19$ for the latter, it is worth noting its presence in case it may have some meaning that escapes us at the moment in light of the known material.
1, $\mathbf{x}+11-\mathbf{x}+15$ : These lines are too damaged to allow any readings. Nevertheless, the months and locations of the planets in the zodiac signs can be estimated by means of the comparison with Stobart tablet A obv., col. II, and the modern computation of the visibility of the planet (cf. Dating, reconstruction of the almanac, and provenance infra).
1, $\mathbf{x}+\mathbf{1 6}$ : This entry ends with what looks like an indication of longitude consisting of the numbers 4,0 and 56 . The rest of the traces before these digits do not include a star determinative, and thus they do not seem to belong to a zodiac sign. The difference in the structure of this entry may be an indication that it provides an additional event for the month of the line above. According to modern computation, this line should correspond to the first evening visibility of Venus. Although the first sign is broken, the word could be read as $h t p$, which makes sense as the designation for evening visibility, probably preceded by some other term to distinguish it from the last evening visibility.

## Fifín

1, $\mathbf{x}+\mathbf{1 7}$ : The zodiac sign for Leo in this text is represented only by the $m 3$ sign, an orthography that is not attested in other texts. ${ }^{10}$ Nevertheless, the representation of a zodiac sign just by a phonetic sign of its name in Demotic is attested in P. Berlin 8279 for Cancer, gnhd, which can be represented just by the phonetic sign $g .{ }^{11}$
1, $\mathbf{x}+19$ : Following the Stobart Tablets (cf. Stobart tablet A obv., col. II.20), I am reconstructing the date on this line as $[h b]$ sw 3 "third epagomenal day." ${ }^{12}$

[^4]The indication of the longitude in this entry ends with a slightly damaged number 5, preceded by the sign for zero. Before this sign the remains of a vertical stroke are preserved between fragment 1 and fragment 7 , which I read as 1 . This structure of the longitude section, with two numbers separated by the sign for zero, appears also in col. $1, x+21$, and col. $2, \mathrm{x}+4, \mathrm{x}+8, \mathrm{x}+9, \mathrm{x}+10, \mathrm{x}+17$, and $\mathrm{x}+19$, and will be discussed in section 7 .
$\mathbf{1}, \mathbf{x}+\mathbf{2 0}$ : Nothing has been preserved of the entry located under the horizontal line, which would probably have contained the year and perhaps the name of the planet of the following section, in this case, Mercury.
1, $\mathbf{x + 2 1}$ : The first sign appears to be the number 7 with the tail slightly broken, followed by the sign for zero. To the left of the latter there is a speck of ink. The space available in the lacuna could accommodate one or two signs. For the structure of this entry cf. section 7. $\mathbf{2 ,} \mathbf{x}+\mathbf{1}-\mathbf{x}+\mathbf{3}$ : The legible part of this column starts with a line that begins with month 2 and preserves only a few traces and the star-determinative of the zodiac sign $(x+3)$. The space above this line fits two lines of which there is almost no trace of ink preserved, but they must have registered the data for month 1 and the title of the section with the indication of the year and the planet, in this case, Jupiter. The position of the planet in Libra in months 1 and 2 can be reconstructed by means of the comparison with other tables and recomputation of the data (cf. Dating, reconstruction of the almanac, and provenance infra).
2, $\mathbf{x + 4}$ : The line starts with day 26 instead of the number of the month, which indicates that this line provides information about a second event in month 2 . This is followed by 20, the sign for zero, and 50 . For the structure of this entry cf. section 7. Comparison with other tables that register the same section of the synodic cycle of Jupiter and modern calculation of the planet's visibility suggest that this entry may have indicated the first visibility of the planet, which would have been registered after the longitude as $\mathrm{pr} m h-1$, as in col. 2, $\mathrm{x}+17$ (cf. Dating, reconstruction of the almanac, and provenance infra).
$\mathbf{2 ,} \mathbf{x}+\mathbf{5}$ : The traces of the first sign indicating the longitude might have 20 in the tens of the degree section.
2, $\mathbf{x}+\mathbf{6}$ : The zodiac sign of this entry has not been preserved, but it can be reconstructed as Scorpio through comparison with other planetary tables and recomputation by means of the Almagest tables (cf. Dating, reconstruction of the almanac, and provenance infra). The indication of a day other than $s w 1$, in this case $s w 6$, shows that we are dealing with a specific event, in this case the entry of the planet in the next zodiac sign.
$\mathbf{2 ,} \mathbf{x + 8}$ : The first sign of the indication of longitude is 6 , followed by a trace that can be interpreted as the lower part of the sign for zero, and a speck of ink showing the presence of a third sign. For this structure cf. section 7.

2， $\mathbf{x + 9}$ ：The traces before the lacuna，after the indication of longitude 7 and 0 ，seem to correspond to another number ending in the horizontal trace before ${ }^{〔} h^{`} m h-1$ ．I suggest the signs 50 and 7，which would fit the length of the lacuna．Another interpretation would be to read in the lacuna a lost part of the designation of the first station．The horizontal trace preserved before the＇$h{ }^{c}$－group could be part of the genitive adjective $n$ ，and the whole group read as $r t n{ }^{〔} h^{〔} m h-1 .{ }^{13}$ Comparison with the traces before the other first station reg－ istered in the papyrus（col．2，$x+22$ ），however，would make this reading unlikely．
$\mathbf{2 ,} \mathbf{x + 1 0}$ ：The data for the longitude in this entry are damaged．The number in the minutes position can be identified as 16 ，preceded by the remains of the sign for zero．The number in the degrees slot has to be smaller than 7，since after the first station indicated in the pre－ vious entry Jupiter is in retrograde．Part of a vertical trace is preserved，which could corre－ spond to either 1,2 or 5 ．I have tentatively read it as 2 based on the expected position of the planet according to the rest of the data（cf．Dating，reconstruction of the almanac，and provenance infra，and Fig．2）．The end of the entry preserves the indication of another synodic phenomenon，labeled as $15 . n t$ ，＂festival of the $15^{\text {th }}$ day．＂${ }^{14}$ It is written with the number 15 over a horizontal line and a $t$ plus the $h b$ sign as determinative corresponds to the acronychal rising of Jupiter（cf．section 6）．I would like to thank Rich－ ard Jasnow for his suggestion of this reading for the sign．
2， $\mathbf{x}+\mathbf{1 1}$ ：The elements preserved for this entry are the remains of number 9 for the month， a day number with 1 in the tens，the Libra zodiac sign，and 52 in the slot for the minutes． The slot for the degrees should be 29 or a lower number close to it，since this line registers the entry of Jupiter in Libra during its retrograde movement（cf．P．Oxy．astron． 4199 recto iii．36）．${ }^{15}$
2， $\mathbf{x}+\mathbf{1 2}$ ：Traces of both number 10 for the month and Libra for the zodiac sign are clearly legible．Between them，some traces can be interpreted as 20 in the tens and perhaps 9 in the units．Illegible traces after the zodiac sign indicate that this line was longer than the previous one．Comparison with other tables as well as modern computation show that the second station of Jupiter happens approximately one month after its acronychal rising． Thus，this entry could have contained a reference to this synodic phenomenon．The length of the entry according to the traces preserved is similar to $\mathrm{x}+9$ ，where the first station is recorded．

[^5]2, $\mathbf{x + 1 3 :}$ This line is badly eroded. Traces of number 11 at the beginning of the line are visible, but the rest of the line is illegible up until the end, where traces of the sign for zero followed by other illegible traces are visible. According to the astronomical data, the zodiac sign can be reconstructed as Libra. This line is as long as $\mathrm{x}+10$, but I cannot propose any interpretation for what the extra information added to it could have been. One possibility is that the second station would have happened at the beginning of this month and not at the end of the previous one. In this case, the name of the event would have been placed before the longitude, since the traces at the end of the line seem to correspond to numbers.
2, $\mathbf{x + 1 4}$ : Although nothing has been preserved of this line, we can reconstruct here the sign as Scorpio through comparison with other tables (cf. Dating, reconstruction of the almanac, and provenance infra).
2, $\mathbf{x + 1 5}$ : Above this entry some traces of a horizontal line separating col. 2 in two parts are visible. To the left of the lacuna, a few traces indicate that this was a short entry, corresponding to the title of the section, which would have probably included the year and the name of the planet, in this case, Mars.
2, $\mathbf{x}+\mathbf{1 6}$ : Traces of number 1 for the month are clearly discernable, followed by a day number with either 10 or 20 in the tens. The number in the units seems to contain at least one hook-like sign, followed by a little trace, perhaps forming either the number 15 or 25 . From the comparison with the date for the entry of Mars in Leo in the Stobart Tablet A obv. col III. 17 I have tentatively reconstructed it as 15 . After the lacuna the traces fit the sign for Leo followed by the star and the small hyphen-like sign introducing the data for the longitude, of which nothing is preserved.
$\mathbf{2 ,} \mathbf{x}+\mathbf{1 7}$ : The units of the day number are not clearly preserved. The preserved traces are a horizontal line with a short vertical on its left end, a speck of ink to its left and a vertical trace that almost touches the sign for Leo, and may or may not belong to it. I have interpreted it as part of the day number, whose traces fit some of the Roman period examples for 25 in Glossar. ${ }^{16}$ After the hyphen-like sign that follows the star determinative of the zodiac sign, the traces might indicate a longitude with degrees in the 20 s, followed by a broken vertical trace, and two specks of ink placed one on top of the other. I have read these traces as 1 for the units of the degrees slot, followed by the zero sign. Following this, a sign like 20 and a vertical stroke with a tick are preserved. This could be the number 21 for the minutes. At the end of the entry, the indication $\mathrm{pr} m \mathrm{~h}$ - 1 notes that this is the first visibility of the planet (for the problems of this indication, cf. Commentary infra). The

[^6]orthography of $p r$ is similar to that of some Ptolemaic and Roman period writings for "house" in Glossar, ${ }^{17}$ as in the London-Leiden Magical Papyrus (col. 12, 1. 31; col. 21, 1s. 3 and 4; col. 23, 1. 22), but here it is the verb pri "to come forth, appear." ${ }^{18}$ which translates the term used in Mesopotamian texts, the Sumerian ideogram IGI, "appearance." ${ }^{19}$ This verb can be written in an abbreviated way as just the $p r$ sign with the ideographic stroke, ${ }^{20}$ which parallels the abbreviations used in Greek papyri for the designation of synodic phenomena.
$\mathbf{2 ,}, \mathbf{x}+\mathbf{1 8}$ : I have reconstructed the units of the day number as 3 , based on the traces preserved. The space after this sign could fit more low signs, and thus correspond to a different number, or be left blank, with the intention of aligning the zodiac sign with that on the previous line.
2, $\mathbf{x + 2 2 :}$ This entry mentions a first station ( ${ }^{( } h^{\ulcorner } m h-l$ ) followed by a little hyphen that might be either the genitive adjective or the same sign that separates the longitude in the other entries. Before ${ }^{〔} h{ }^{`}$ there is a vertical stroke with part of a ligature to another sign. According to the structure of these tables, we would expect an indication of the day at the beginning of this line to note that this is the second event for month 6 (since the entry on $\mathrm{x}+21$ refers to the entry of Mars in Libra). The traces could correspond to either 11 or 21. In this case, the synodic event seems to have been mentioned before the longitude in which it takes place.
2, $\mathbf{x}+\mathbf{2 3}$ : Before the sign for Libra, traces similar to those on line $\mathrm{x}+22$ are preserved. Here we would expect a day number. The traces look like 21, but this is not the common shape for day numbers in Demotic, which are used consistently in this table. Above the sign for Libra on this line, a small sign that looks like Virgo has been added, perhaps indicating a correction, since after the first station indicated in the previous line, the planet has started its retrograde movement, entering Virgo again after having crossed to Libra in month 6. If the movement of Mars here corresponds to the same section of the synodic cycle of Mars as that in Stobart A obv. III, 16-22, reentry in Libra would happen towards the end of the year (in that case, month 11). ${ }^{21}$
2, $\mathbf{x + 2 4 :}$ Only a few traces survive of this line, but their shape fits that of the sign for Virgo.

[^7]
## Fragment 3

$\mathbf{x + 1}$ : The shape of the zodiac sign does not correspond to any of the ones preserved in the other fragments. Thus, it has to belong to the range between Aries and Cancer, of which the traces better fit the symbol for either Taurus (the phallus-determinative) or Gemini. ${ }^{22}$ Since the placement of this fragment is not known, context cannot help in the identification of the sign.

## Fragment 4

$\mathbf{x + 3}$ : The traces left for this sign correspond to those of Pisces as in Fr. $1+2+5+6+7$, col. 1, $\mathrm{x}+10$.
$\mathbf{x}+4$ : The only preserved part of the zodiac sign is a single diagonal trace below the stardeterminative. This could correspond to the Pisces sign, as in the line above, without the little hook at the end, or to Aries written with the animal skin sign, as in P. Florence 8, 1. 8. ${ }^{23}$

## 5. Commentary

## Interpretation of the contents

P. Monts.Roca inv. 314 contains part of two columns of a monthly almanac, plus two unplaced fragments (Frs. 3 and 4). Fr. 1+2+5+6+7, col. 2 preserves complete entries, which start with an indication of the month written with normal demotic cardinal numerals, from 1 to 12 (cf. Table 1). The next section contains the day of the month, written with the special demotic day numbers and introduced by a small angular-shaped sign for $s w$, "day," which derives from the sun $\operatorname{disk}^{24}$ (cf. Table 2). The position of the planets along the ecliptic is given by the zodiac sign and the longitude in degrees and fractions of degrees. The zodiac signs are indicated by one single sign plus a star determinative (cf. Table 3). Only those signs in the range from Leo to Pisces are attested, with Sagittarius partially preserved in Fr. $1+2+5+6+7$, col. 1, $x+7$, and possibly Gemini in Fr. 3, $x+1$. The shapes of the signs are the same as those in P. Carlsberg 638, which preserves Scorpio, Sagittarius, Capricorn, Aquarius, Pisces, and Aries, also with a star determinative, ${ }^{25}$ and similar in

[^8]some cases, but not all, to those from P. Berlin 8279 and the Stobart Tablets. ${ }^{26}$ In two instances on Stobart E a star determinative is added to the zodiac signs (for Taurus in obv. I, 1 ; and Aries in rev. V, 1). ${ }^{27}$ The longitudes are given in cardinal numbers (cf. Table 4). Between the zodiac sign and the longitude there is a little hyphen-like sign in many but not all the columns (cf. notes to Fr. $1+2+5+6+7 \mathrm{col} .1 \mathrm{x}+4$ ). The degrees corresponding to each zodiac sign range in this table from 0 to 29 . The lowest numeral preserved in the first position is $0,{ }^{28}$ and the highest $21 .^{29}$ In the second position we find numerals from 0 to $57,{ }^{30}$ corresponding to the sexagesimal fractions of degree. The fifth position in the table is occupied only for some entries, indicating particular events in the synodic cycle of the planet in question. These will be discussed in detail below.

Concerning the specific data recorded in the table, no dates or names of planets have survived for any of the sections. Column 1 only preserves the information corresponding to the location of the planets on the ecliptic (zodiac sign and longitude), but not the dates associated with each of those positions, except for day 3 on line $x+19$. The presence of traces of a horizontal line between $\mathrm{x}+19$ and $\mathrm{x}+20$ indicates that the data located before the line correspond to the same planet. Although lines $x+11-x+15$ are illegible, the format of the monthly almanacs indicates that at least 12 entries are expected for each planet each year. This means that all the entries above the horizontal line belong to the same planet. Therefore, at least 16 entries have been noted for this planet. The movement recorded, with at least two sign entries in what has to be the same month for some lines, indicates that the planet in question is an inner planet, in this case, Venus. One synodic event may be preserved in this column. ${ }^{31}$ Column 2, on the contrary, contains many complete entries for two sections, which correspond to two planets. The upper section registers the movement of Jupiter, and the lower section that of Mars. Each entry corresponds to a month, except for line $\mathrm{x}+4$, which seems to contain an extra line of information for month 2, since it starts with $s w$ 26. Those months in which neither a sign entry nor a synodic event take place give the position of the planet for day 1.

The structure of the table preserved in P. Monts.Roca inv. 314 follows the normal Greek order of the planets: Saturn, Jupiter, Mars, Venus, Mercury. Thus, column 1 preserves data for Venus and Mercury corresponding to one year, followed in column 2 by

[^9]data for Jupiter and Mars in the consecutive year. Between both columns all the entries for Mercury except for a fragment of the first one are missing, together with those for Saturn. In order to estimate the number of lines lost, we need to calculate the number of sign entries and synodic events for Mercury and Saturn in years 4 and 5 of Vespasian respectively ( $71 / 72$ and $72 / 73 \mathrm{CE}$ ). ${ }^{32}$ Starting with Saturn, modern computation of its visibility gives the following events for year 5 of Vespasian: ${ }^{33}$

- Last visibility ( $\Omega$ ): 4-III (31 Oct.), ML 25;22.
- First visibility (Г): 4-IV (30 Nov.), ML 28;49.
- First station ( $\Phi$ ): 13-VII (9 Mar.)-19-VII (15 Mar.), メ 5; 25. ${ }^{34}$
- Acronychal rising ( $\Theta$ ): 16-IX (11 May), ス̌ 3;20.
- Second station ( $\Psi$ ): 3-XII (27 Jul.)-10-XII (3 Aug.), Ml 28;23.

The total of entries for Saturn would be 13 plus title, since only month 9 would have had two events: sign entry in Scorpio and acronychal rising. ${ }^{35}$ In the case of Mercury, comparison with the section for Venus indicates that synodic events were recorded in additional entries in the case of the inner planets. We should expect to find first and last morning visibility, and first and last evening visibility. ${ }^{36}$ For year 4 of Vespasian (71/72 CE) we have 13 of these synodic events for Mercury, which added to the sign entries indicated in Stobart Tablet A obv. would make a total of 25 entries plus title. ${ }^{37}$ The title line and the

[^10]first line of Mercury are partially preserved in Fr. 7, and the section for Venus would have started approximately in the top part of Fr. 1. The height of Fr. 1 is 11.4 cm (Fr. 7 attached to Fr. 1 does not add to its height). Since the separation between lines in P. Monts.Roca inv. 314 is quite regular, 38 lines ( 24 for Mercury not counting the title and first line preserved in col. 1, and 14 for Saturn) would occupy in the table ca. 20.8 cm (calculated considering that the distance occupied by lines $x+4$ to $x+13$ in column 2 is ca. 5.2 cm ). These may have been distributed toward the upper or lower parts of the section of the table preserved here, with the possibility of one of the sections for these planets being divided between column 1 and 2 . In any case, the total height of the complete papyrus would have been around 32.2 cm without margins. The average height for a papyrus roll in the Roman period was between 25 and $33 \mathrm{~cm} .{ }^{38}$

## Dating, reconstruction of the almanac, and provenance

The proposal of a date for the astronomical data recorded in the almanac and the reconstruction of part of the missing information are possible by means of its modern recomputation, and the comparison with other planetary tables in Greek and Demotic. Beginning with col. 2, the section of the synodic cycle of Jupiter recorded in it corresponds to that in P. Oxy. astron. 4199, a Greek monthly almanac of Jupiter, and specifically to lines 28 to 39. ${ }^{39}$ These record data for year 19 of Augustus ( $12 / 11 \mathrm{BCE}$ ). It is interesting to note that the correspondence of the data recorded is identical with respect to the months, and very close even in the days, especially in the cases of the first station of Jupiter taking place in month 7 day 1 in both cases (P. Oxy. astron. 4199 recto 1. 34, and P. Monts.Roca inv. 314 Fr. $1+2+5+6+7$ col. $2 x+9$ ), the acronychal rising in month 8 day 30 in the case of $P$. Oxy. astron. 4199 (recto 1. 35) and in month 8 day 28 for P. Monts.Roca inv. 314 (Fr. $1+2+5+6+7$ col. $2 \mathrm{x}+10$ ), and the second station in month 10 day 30 for P. Oxy. astron. 4199 (recto 1. 37) and in month 8 day 29 for P. Monts.Roca inv. 314 (Fr. $1+2+5+6+7$ col. $2 \mathrm{x}+12$ ). This allows us to reconstruct Libra in both month 1 and $2(x+2, x+3)$, and the first visibility in month 2, probably in the second entry for it, line $x+4$. The date in P. Oxy. astron. 4199 pins the movement of Jupiter recorded in P. Monts.Roca inv. 314 to a date in the great cycle of Jupiter, which will be useful in order to provide a date for it.

[^11]Another document that records the same section of the synodic cycle of Jupiter is P. Berlin 8279 + P. Berlin 23547. This is a sign-entry almanac from the Fayum for years 16 BCE to $11 \mathrm{CE},{ }^{40}$ and thus it records the data for year 19 of Augustus, differing slightly from the information in P. Oxy. astron. 4199. P. Berlin 8279+P. Berlin 23547 also includes the data for the other four planets. A comparison of the data for Mars in both P. Berlin 8279 + P. Berlin 23547 and in P. Monts.Roca. inv. 314, however, shows important differences. The entry of Mars in Virgo, which happens in month 3 in P. Monts.Roca inv. 314 , is recorded for month 11 in P. Berlin $8279+$ P. Berlin 23547. Therefore, the information in P. Monts.Roca inv. 314 cannot correspond to year 19 of Augustus (12/11 BCE).

A sign-entry almanac which records the same dates as P. Monts.Roca inv. 314 in most of its entries is the Stobart Tablet A obv. Column III, lines 11-15 and 16-22 record the sign-entries for Jupiter and Mars, respectively, in year 5 of Vespasian (72/73 CE). The preserved entries of Jupiter in Scorpio and Libra happen in the same months as in P. Monts.Roca inv. 314, and at least in the first entry in Scorpio on the same day (in the case of Libra, on a day in the second decade of the month in both tables, since the day number is not completely preserved in P. Monts.Roca inv. 314, col. 2, $x+11$ ). In the case of Mars, sign entries in Leo and Virgo happen in the same months, and in both cases on a day in the second decade of the month. If we look at the information for Venus in the previous year (4 of Vespasian), we can see that the succession of signs preserved corresponds to the sequence in col. 1 of P . Monts.Roca inv. 314, including the date in the third epagomenal day, [hb] sw 3, of line $\mathrm{x}+19^{41}$ (Stobart A obv. col. II.20).

In conclusion, according to the comparison with these other tables, the information recorded in P. Monts.Roca inv. 314 would belong to the years 4 and 5 of Vespasian (71-73 CE). The great cycles of Jupiter attested in cuneiform Goal-Year texts are of 71 and 83 years. ${ }^{42}$ Thus, the data for Jupiter recorded in P. Oxy. astron. 4199 (12/11 BCE) and in P. Monts.Roca inv. 314 (72/73 CE) would correspond to two successive great cycles of the planet.

The modern recomputation of the data further confirms this dating, and allows the reconstruction of some missing entries. First, however, it is necessary to ascertain which calendar is the one employed in the almanac. No specific reference to the intercalation of a sixth day is recorded. However, many of the dates correspond to those in the Stobart Tab-

[^12]let A obv．，which Neugebauer computed and arrived at the conclusion that they agreed with the modified Alexandrian calendar．${ }^{43}$ The comparison of the data from P ． Monts．Roca inv． 314 to the recomputed positions of each planet according to the Alexan－ drian and Egyptian calendars shows that，particularly in case of Jupiter，the agreement with the Alexandrian dates is closer（cf．Fig．1－3）．

The following tables summarize the data recorded in the almanac．The data in P ． Monts．Roca inv． 314 are contrasted with recomputed dates and planetary positions using the Almagest tables（corrected for a sidereal frame of reference），${ }^{44}$ and with the data in the Stobart Tablet A obv．The entries for synodic events are indicated in bold．${ }^{45}$ Those entries labeled as＂cal．＂correspond to data recomputed by means of the Almagest tables，while those with the tag＂cal．PLSV＂correspond to synodic events calculated by means of the program Planetary，Lunar，and Stellar Visibility．${ }^{46}$

The data for Venus consist mostly of sign entries．Although no dates have been pre－ served in P．Monts．Roca inv．314，I have reconstructed the months and the contents for each of the missing lines by means of the combination of the dates for the sign entries of Venus in the Stobart Tablet A obv．，together with the modern computation of its synodic phenomena for year 4 of Vespasian．

Venus（year 4 of Vespasian，71／72 CE）

| P．Monts．Roca inv． 314 |  | Recomputation（Almagest，sidereal） |  | Stobart Tablet A obv． |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| ［I］ | ［ 0$]$ | cal．1－I（30 Aug） | O）1；32 | 1－I | $\Omega$ |
| ［II］ | ［TD］0；x9 | cal．10－II（8 Oct） | mp 0；36 | 11－II | mp |
| ［III］ | 气 0；x5 | cal．8－III（5 Nov） | $\Omega$ 亿；47 | 9－III | $\Omega$ |
| ［IV］ | m 0；08 | cal．3－IV（30 Nov） | m 0；06 | 4－IV | $m$ |
| ［IVbis］ | 入 $0 ; 52$ | cal．28－IV（25 Dec） | 入 0；26 | 29－IV | 入 |
| ［V］ | V9 1；00 | cal．23－V（19 Jan） | V9 1；12 | 23－V | Vs |
| ［VI］ | $\approx 0 ; 12$ | cal．17－VI（12 Feb） | $\approx 0 ; 49$ | 18－VI | $\approx$ |

[^13]| [VII] | H 0;18 | cal. 11-VII (7 Mar) | H 0;22 | 12-VII | H |
| :---: | :---: | :---: | :---: | :---: | :---: |
| [VIII] | [९] | cal. 6-VIII (1 Apr) | P 1;00 | 7-VIII | $\bigcirc$ |
| [VIIIbis] | [ $\Sigma$ | $\begin{aligned} & \text { cal. PLSV 13-VIII (8 } \\ & \text { Apr) } \end{aligned}$ | cal. $\uparrow 9 ; 33$ <br> cal. PLSV $\uparrow 9 ; 46$ |  |  |
| [IX] | [ర] | cal. 30-VIII (25 Apr) | ૪ 0;17 | 1-IX | $\bigcirc$ |
| [IXbis] | [II] | cal. 25-IX (20 May) | ㅍ 0; 43 | 26-IX | II |
| [X] | [ซ] | cal. 20-X (14 Jun) | כ 1;09 | 20-X | $\sigma$ |
| [Xbis] | $\Xi[$ [] 4;56 | $\begin{aligned} & \text { cal. PLSV 18-X (12 } \\ & \text { Jun) } \end{aligned}$ | cal. I 28;43 <br> cal. PLSV © 0;18 |  |  |
| [XI] | ه̧ 0;50 | cal. 14-XI (8 Jul) | ภ- 0;28 | 14-XI | O |
| [XII] | mp 0;26 | cal. 9-XII (2 Aug) | mp 1;08 | 8-XII | $m$ |
| 3-[XIII] | $\Omega$ 1;05 | 3-XIII (26 Aug) | $\Omega$ 亿 0;43 | 3-XIII | $\Omega$ |

In the case of Jupiter, the almanac registers the entry in Scorpio in month 4 day $6(x+6)$, and the retrograde entry in Libra in month 9 in a day in the tens of the month $(x+11)$. The longitudes recorded in P. Monts.Roca inv. 314 tend to differ from those resulting from the recomputation according to the Almagest tables by an average of $3^{\circ}$, which is not a significant deviation in the case of Jupiter. The almanac also records synodic events for Jupiter. ${ }^{47}$ Those preserved are the first station of Jupiter in month 7 day $1(x+9)$, acronychal rising of Jupiter in month 8 day $28(x+10)$, and second station in month 10 day $29(x+12)$. The agreement of the date of the first visibility of Jupiter is exact with that obtained through modern recomputation. In the case of the acronychal rising, the difference is of 6 days and about $5^{\circ}$ of deviation.

[^14]Jupiter (year 5 of Vespasian, 72/73 CE)

| P. Monts.Roca inv. 314 |  | Recomputation (Almagest, sidereal) |  | Stobart Tablet A obv. |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| [I] | [ $\Omega$ ] | 1-I (29 Aug) | ת 11;40 | 1-I | $\Omega$ |
| II | $[\Omega] \Omega$ | $\begin{aligned} & \text { cal. PLSV 29-I }(26 \\ & \text { Sep) } \end{aligned}$ | cal. $\Omega$ 17;33 <br> cal. $P L S V \Omega 18 ; 18$ |  |  |
| 26-II | $[\Gamma](\Omega) 20 ; 5 x$ | $\begin{aligned} & \text { cal. PLSV 26-II (23 } \\ & \text { Oct) } \end{aligned}$ | cal. $\Omega$ 23;27 <br> cal. $P L S V \Omega 24 ; 09$ |  |  |
| 1-III | $\Omega 2 \mathrm{x} ; \mathrm{xx}$ | 1-III (28 Oct) | $\Omega 24 ; 32$ |  |  |
| 6-IV | [m] | $\begin{aligned} & \hline \text { 6-IV (2 Dec) } \\ & \text { cal. 28-III (24 Nov) } \end{aligned}$ | $\begin{aligned} & m_{1 ; 40} \\ & m_{0} 0 ; 07 \end{aligned}$ | 6-IV | $m$ |
| 1-V | $m$ | 1-V (27 Dec) | m 5;55 |  |  |
| 1-VI | m. 6;xx | 1-VI (26 Jan) | m. 9;27 |  |  |
| 1-VII | Ф M. 7; 57 | $\begin{aligned} & \hline \text { 1-VII (25 Feb) } \\ & \text { cal. 26-VI (20 Feb)-1- } \\ & \text { VII (25 Feb) } \end{aligned}$ | M. 10;37 M. 10;37 |  |  |
| 28-VIII | © m. 2;16 | 28-VIII (23 Apr) <br> cal. PLSV 22-VIII (17 <br> Apr) | cal. M. 5;55 <br> cal. PLSV M, 7;27 |  |  |
| 1x-IX | 气 $\mathrm{xx} ; 52$ | 10-IX (5 May)-19-IX <br> (14 May) <br> cal. no retrograde entry in $\Omega$ | m. 4;23-m. 3;19 | 16-IX | $\Omega$ |
| 29-X | $[\Psi] \Omega$ | $\begin{aligned} & \text { 28-X (22 Jun) } \\ & \text { cal. 29-X (23 Jun)-2- } \\ & \text { XI (26 Jun) } \end{aligned}$ | $\begin{aligned} & \text { m. } 0 ; 46 \\ & \text { m. } 0 ; 45 \end{aligned}$ |  |  |
| XI |  | 1-XI (25 Jun) | m 0;45 |  |  |
| XII |  |  |  | 16-XII | $m$ |

The almanac records four sign entries for Mars: possible entry in Leo in month 1 in a day in the tens, probably $15(x+16)$, entry in Virgo in month 3, possibly day $13(x+18)$, entry in Libra in month 6 day $3(x+21)$, and a retrograde entry in Virgo in month $7(x+23)$. It also preserves indications of synodic events. There is a first station of Mars probably in month 6 , with no day preserved ( $x+22$ ). Column 2 , line $x+17$ notes the first visibility of

Mars in month 2 in a day in the twenties, perhaps 25 . However, the modern computation of the synodic events of Mars for this synodic cycle shows that the first visibility took place in month 10 day 20 ( 14 Jun.) of the previous year (year 4 of Vespasian, 71/72 CE), when the planet was in Gemini $5 ; 10$. This mistake can be understood as a scribal error, in which the scribe may have seen the indication of the first visibility of Jupiter in month 2 above (col. 2, $x+5$ ), and mistakenly copied the same synodic event in month 2 for Mars as well. The section for Mars seems to have a correction in line $\mathrm{x}+23$, in which the sign for Virgo has been added above the line. This may be an indication that the scribe was distracted while copying these entries.

Mars (year 5 of Vespasian, 72/73 CE)

| P. Monts.Roca inv. 314 |  | Recomputation (Almagest, sidereal) |  | Stobart Tablet A obv. |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 15-I | $\Omega$ | 15-I (12 Sep) | ภ 2;19 | 16-I | $\Omega$ |
| 25-II | $\Gamma$ ¢ 21;21 | 25-II (22 Oct) | cal. $\Omega$ 25;09 <br> cal. PLSV no $\Gamma$ |  |  |
| 13-III | mp 0;xx | cal. 13-III (9 Nov) <br> cal. 5-III ( 1 Nov ) | $\begin{aligned} & m p ; 37 \\ & m p ; 29 \end{aligned}$ | 11-III | m |
| 1-IV | mp 8;xx | 1-IV (27 Nov) | mp 13;23 |  |  |
| 1-V | m 19;xx | 1-V (27 Dec) | m 25;33 | 6-V | $\Omega$ |
| 3-VI | $\Omega$ | $\begin{aligned} & \text { 3-VI (28 Jan) } \\ & \text { cal. 17-V (12 Jan) } \end{aligned}$ | $\begin{aligned} & \Omega 2 ; 34 \\ & \Omega 0 ; 06 \end{aligned}$ | 24-V | m |
|  | Ф | $\begin{aligned} & \text { cal. 8-VI (2 Feb)-10-VI } \\ & \text { (4 Feb) } \end{aligned}$ | ת 2;48 |  |  |
| [VII] | m | cal. 1-VII (25 Feb) | mp 29;54 |  |  |
|  | $[\Theta] \mathrm{m}$ | $\begin{aligned} & \hline \text { cal. PLSV 11-VII (7 } \\ & \text { Mar) } \end{aligned}$ | cal. Tp 26;45 <br> cal. PLSV 27;51 |  |  |
|  |  | cal. 30-VIII ( 25 Apr ) | $\Psi \mathrm{TP}^{\mathbf{1 4}} \mathbf{5 4}$ |  |  |
|  |  |  |  | 1-XI | $\Omega$ |
|  |  |  |  | 19-XII | $m$ |

The next question is the dating of the manuscript itself. There is no internal reference to when the table was composed, and the traces of text on the verso do not offer any clues
that could be used as reference points for its dating. Thus, only palaeography can serve as a dating criterion for P . Monts.Roca inv. 314. As was indicated above, P. Monts.Roca inv. 314 has the same or a very similar hand as P. Carlsberg 638. This papyrus contains a lunar ephemeris dated by A. Jones to year 13/14 CE. About its date of composition, Jones considers that "Probably the papyrus was written within a few months, or at most within a year or two, of those dates," noting that this would probably push back to the first century BCE the invention of the Standard Scheme used to compute the dates. ${ }^{48}$ In his study of the palaeography of P. Carlsberg 638, F. Hoffmann gives a dating not later than the first century CE, based on the orthography of $s w$ in the day numbers as a small angular sign, which according to him is attested mostly in the Ptolemaic period, together with the writing of some of the date numbers, only attested in the Ptolemaic period. He narrows the dating down to between 50 BCE to 70 CE , with a more probable time frame of 30 BCE to $50 \mathrm{CE} .{ }^{49}$ The fact that P. Monts.Roca inv. 314 seems to display the same or a very similar hand as P. Carlsberg 638 would place it close to the date of composition of the latter, i.e. in the second decade of the first century CE according to Jones. However, if the dating of the astronomical information presented here is correct, and since monthly almanacs are generally considered to have been composed after the date of the information they register, P. Monts.Roca inv. 314 would need to be dated in the fourth quarter of the first century CE, or even in the early second century. ${ }^{50}$ This would move the date of composition of P. Carlsberg 638 forward. Technically this would not be a problem. P. Berlin 8279 was copied sixty years after the earliest date of the information it records, and the Greek P. Oxy. astron. 4199 registers information for the late first century CE but was not copied before the mid second century CE. ${ }^{51}$ Furthermore, Demotic palaeography is far from being as precise a dating criterion as Greek. A closer look at the instances of day numerals in Glossar shows that the use of the angle-like $s w$ sign is frequent both in the Roman period and in Ptolemaic times. Thus, a dating in the late first century to the early second century CE for both P. Monts.Roca inv. 314 and P. Carlsberg 638 is not out of the question.

Finally, concerning the provenance of P. Monts.Roca inv. 314, no specific records are preserved. According to Kim Ryholt, the origin of P. Carlsberg 638 is not Tebtunis, ${ }^{52}$ and thus we may infer the same for P. Monts.Roca inv. 314.

[^15]
## 6．Demotic names of the events in the synodic cycle of the planets

Some of the entries in Fr． $1+2+5+6+7$ col． 2 include indications of events in the synodic cycle of the planets．These correspond to two outer planets，Jupiter and Mars．Evening first may be preserved for Venus in col．1．${ }^{53}$ This kind of data appears in Babylonian and Greek astronomical texts，but had not been attested in Demotic so far．The synodic cycle of an outer planet is composed of five phases：first visibility，first station，acronychal ris－ ing，second station，and disappearance．Only the first three are attested in P．Monts．Roca inv． 314 （cf．Table 5）：
－First visibility：Fr． $1+2+5+6+7$ col． $2, x+17$ indicates the first visibility of Mars as $p r m h-1$（for the orthography of $p r$ cf．textual notes supra）．This designation is not sur－ prising，since the word pr．t is that used for the heliacal rising of stars，such as pr．t－spd．t， the heliacal rising of Sirius（ Wb ．I，525．12）．For the connection of this term with the symbol used in Greek tables to indicate this phase，cf．section 8.
「h「 $m h-1$ ，perhaps to be reconstructed as $r r_{1} n{ }^{〔} h^{`} m h-1$（cf．textual notes supra）．This corresponds very closely with the expression used in Greek papyri，стпрı $\boldsymbol{\mu} \tilde{̣}^{\alpha} \alpha$＇＂in the first station．${ }^{54}$
－Acronychal rising：Fr． $1+2+5+6+7$ col． $2, x+10$ indicates the acronychal rising of Jupi－ ter as $15 . n t$ ，generally used to designate the festival of the fifteenth day of the month，which corresponds to the full moon（for the orthography of the word，cf．textual notes supra）．The reading of this word has been considered as uncertain in the editions of the texts in which it is attested in Demotic．F．Ll．Griffith and H．Thompson noted it in the＂uncertain reading＂section of the third volume of their edition of Magical，trans－ lating it as＂ $15^{\text {th }}$ day of the month．＂${ }^{55}$ The term appears there three times（XXII，23； XII，23；X，22），always described as the day when the moon has filled the wedjat－eye， i．e．the full moon．In his edition of the Opening of the Mouth，where it is attested twice （P．Straßburg 3 vs， $\mathrm{x}+1,5$ ；P．Berlin 8351，III 16），M．Smith also included it in the sec－ tion about＂words of uncertain meaning，＂defining it as＂name of the half month festi－

[^16]val. ${ }^{n 56} \mathrm{He}$ noted that the word is connected both here and in P. Harkness (IV, 30) with the festival of the $6{ }^{\text {th }}$ day. ${ }^{57}$ Both were festivals dedicated to the cult of the dead, in which offerings were presented to them by their relatives, and the $15^{\text {th }}$ day was described in P. Harkness as hrw n swtwt "day of promenading" of the deceased. ${ }^{58}$ The Egyptian term for acronychal rising is thus the one used for the full moon, which can be explained because the moon is full when it is in opposition ( 180 degrees) from the sun, which is also the position in which the planet is with respect to the sun when it is in its acronychal rising. ${ }^{59}$ It is interesting to note that the $15^{\text {th }}$ day of the month, which was identified with the full moon, is in the middle of the month, dividing it in two parts, and the acronychal rising of an outer planet happens in the middle of its retrograde movement between its first and second stations. These parallelisms between the cycle of the moon and the synodic cycle of the outer planets may have been the reason for the choice of $15 . n t$ for the designation of the acronychal rising or opposition. However, I am not aware of the use of this term referring to planets in any other Egyptian text. The term used in Greek papyri, ג́крóvozos "at nightfall," thus refers to the moment in which the celestial body is seen on the eastern horizon with respect to the sun. ${ }^{60}$ In Akkadian texts, the opposition is expressed with the term ana ME E- $a$ (literally "it comes up to day(light)"), abbreviated as ME E or E. ${ }^{61}$

## 7. A secondary use of the sign for zero in Demotic astronomical papyri

The sign for zero in Demotic astronomical papyri consists of a horizontal line with a tick on top, and a small angle-like trace below, $\boldsymbol{\mathcal { L }}$. It is attested 22 times in P. Monts.Roca inv. 314 (Fr. $1+2+5+6+7$, col. $1, x+4, x+5, x+6, x+7, x+8, x+9, x+10, x+16, x+17, x+18$, $\mathrm{x}+19, \mathrm{x}+21 ; \operatorname{col} .2, \mathrm{x}+4, \mathrm{x}+8, \mathrm{x}+9, \mathrm{x}+10, \mathrm{x}+13, \mathrm{x}+17, \mathrm{x}+18, \mathrm{x}+19 ; \operatorname{Fr} .3 \mathrm{x}+2 ; \operatorname{Fr} .4 \mathrm{x}+3$; cf. Table 4). ${ }^{62}$ In 2005 F . Hoffmann published an article in which he analyzed a similar

[^17]sign only attested in one Demotic astronomical papyrus, in P. Carlsberg 32 (a template for Mercury), where the sign appears complete in col. 2, line 4, and fragmentarily preserved in col. 1, lines 6, 7, and twice in line 11. It is also attested in P. Wien D 12006 (oracles based on a system of three digits). Hoffmann arrived at the conclusion that the sign corresponds to the Demotic iwt "without, ${ }^{, 63}$ indicating the absence of a number, and not actually representing a numeral. He also pointed out that the symbol used in Greek astronomical papyri to indicate 0 is similar to the demotic sign and may derive from it. ${ }^{64}$ The numerous attestations of the sign in P. Monts.Roca inv. 314 and their similarity to some of the attestations of the symbol in Greek papyri seem to confirm Hoffmann's suggestion, and constitute the clearest attestations for this sign to my knowledge.

The normal use of the sign for zero, shared by both the Demotic and Greek astronomical texts, is to indicate an empty place either in the degrees or in the sexagesimal fractions of degrees, in the recording of positions of celestial bodies. However, P. Monts.Roca inv. 314 contains at least 9 attestations of a secondary use of this sign. In Fr. 1+2+5+6+7, col. $1, \mathrm{x}+16, \mathrm{x}+19, \mathrm{x}+21$, and col. $2, \mathrm{x}+4, \mathrm{x}+8, \mathrm{x}+9, \mathrm{x}+10, \mathrm{x}+17, \mathrm{x}+19$ the sign is used as a way to separate the digits corresponding to the degrees and minutes. This use of the sign for zero is well attested in cuneiform astronomical texts, and was first described by Neugebauer. ${ }^{65}$ The cuneiform sign for zero, $\mathbb{4}^{4},{ }^{66}$ was originally a punctuation mark to separate sentences. Its secondary use is attested mainly in texts from Uruk, but also in some examples from Babylon. ${ }^{67}$ In cuneiform astronomical texts, the sign for zero is only used after the numbers $10,20,30,40$, or 50 , and before 1 to 9 , since "the intention of this 'zero' sign is to separate tens from units in order to preclude misreadings. ${ }^{,{ }^{68}}$ However, in P. Monts.Roca inv. 314 the sign seems to have been used in every case in which there is not a zero in either the degrees or the minutes slot, even in cases in which there is no ambiguity in the reading of the longitude.

Was the secondary use of the sign for zero in Demotic derived from that of the cuneiform sign? One of the main problems in approximating an answer to this question is the

[^18]lack of enough comparanda, since P. Monts.Roca inv. 314 is so far the only attestation of this use of the sign in Demotic. Furthermore, I am only aware of this use in Greek astronomical papyri in one instance, P. Oxy. astron. 4136, 1. 5, a procedure text for the moon dating to the first century CE. ${ }^{69}$ While the sign used in Mesopotamian texts originally had the function of separating elements, this was not the case with the sign for zero in Demotic. The Demotic sign itself is not derived from the cuneiform one, but as Hoffmann has shown, its origin is entirely Egyptian. ${ }^{70}$ However, its main use to indicate empty places in the units or sexagesimal fractions of the longitudes of the celestial bodies is equivalent to that of the cuneiform sign for zero in Mesopotamian astronomical texts. The secondary use of the Demotic sign for zero may have been derived from that of the cuneiform sign. However, two main problems arise in this consideration. First, while the cuneiform sign is used only as a separation in those cases in which the placement of the digits would lead to ambiguities in their interpretation, the Demotic sign is used in all the instances in which both the degrees and minutes slots are different from 0 . Second, the practice of using a sign regardless of its regular meaning to separate numbers and avoid ambiguities is attested in Demotic. Neugebauer pointed out in his 1941 article that the Stobart Tablets "avoid the juxtaposition of month 10 and day dates less than 10 by inserting the sign 'day' before the units. ${ }^{י 71}$ However, this practice is not just the use of a sign to separate digits, but also involves the use of a different set of numbers accompanying said sign. Therefore, it is not entirely parallel to the use of the sign for zero as divider.

In conclusion, the available evidence does not allow us to determine if this secondary use of the Demotic sign for zero was adopted in Egypt from its use in cuneiform astronomical texts, or if it was an independent development by the Egyptian scribes. The publication of new Demotic astronomical tables may shed some light on this issue.

[^19]8. Hypothesis for the interpretation of the sign for first and last visibility ${ }^{72}$ in the Greek astronomical papyri
The Greek planetary tables that indicate the synodic phenomena of the planets normally used abbreviations of the Greek terms for each one of the events consisting of one to three of the first letters of the word. An exception to this was the notation for the first and last visibility, which were indicated with a sign composed of "a small circle with ascending diagonal tail" ${ }^{73}$ Concerning this sign A. Jones points out that "These notations seem to have died out in late antiquity, perhaps with the diminishing importance of the phenomena they signified. ${ }^{, 74}$ To my knowledge no explanation for this sign is given in any of the editions of Greek astronomical papyri.

I have already discussed in the previous section that Hoffmann has proposed that the sign used for zero in Greek astronomical papyri may derive from the Demotic sign iwt "without" (cf. footnote 64), employed to indicate the absence of a number in Demotic astronomical papyri. In the case of the sign used in Greek papyri for first and last visibility, a similar process can be suggested.

The indication of first visibility of Mars attested in P. Monts.Roca inv. 314 (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+17$ ) uses the expression $p r m h-1$, as noted above. The orthography of $p r$ in this case consists of a horizontal trace, under which the house sign is represented by a circular shape plus the ideographic stroke $\dot{\boldsymbol{\alpha}}$. In other writings of this word from the Roman period, however, the horizontal trace has a little curve at its left end, which in some attestations forms a small loop. ${ }^{75}$ This loop can be found in writings of pr "house" such as the graffito Philae 159.6, $\sigma_{八},{ }^{76}$ or in $p r$ (written as $p r-h d$ ) in Magical 10/9,
 ness $4 / 6,5 / 28$, and $6 / 15,3$ P0. (facsimile of $5 / 28$ ) the horizontal trace conflates with the walking legs, creating in some instances a long flourish over the word. ${ }^{78}$ The walking legs

[^20]sign in itself can adopt the form of a loop, as in pri in Onchsheshonqy 7/24 6n-4.$^{79}$ The verb pri appears abbreviated as just the walking legs already in the Old Kingdom. ${ }^{80}$

Thus, I propose that the sign used in Greek astronomical tables to indicate first and last visibility comes from the use of $p r$ in Demotic papyri to indicate first visibility, which in other instances apart from P. Monts.Roca inv. 314 may have looked like a loop, either deriving from the horizontal trace in $p r$ or from the walking legs sign. This process would be parallel to that of the adoption of the sign for zero from Demotic to Greek astronomical tables, and provides further hints regarding the transmission of astronomical knowledge in Antiquity, as will be described in the following section.

## 9. Remarks on the place of Egyptian astronomy in the context of the transmission of scientific knowledge during the Hellenistic and Roman periods

The study of Graeco-Egyptian astronomy has arrived at a stage of development in which the corpus of texts published allows their systematization and their analysis in order to attempt an understanding of their origin and place in the wider context of astronomy in the ancient Near East and the Mediterranean. ${ }^{81}$ In contrast to the general opinion held before that Egypt played a secondary role in the history of astronomy, already in 1994 A. Jones pointed out the importance of Egyptian astronomy in the transmission of astronomical and astrological knowledge between Mesopotamia and the Greeks, since Egypt was the place where the Greeks were most exposed to this information. ${ }^{82}$ In 1999 he nuanced this statement indicating that this process was not just one of transmission, but also of transformation, ${ }^{83}$ an argument developed by F. Hoffmann in an article where he analyzed specifi-

[^21]cally the issue of the transmission of scientific knowledge in Hellenistic Egypt. ${ }^{84}$ In this article, Hoffmann emphasizes the necessity of looking at the actual primary sources in order to redefine old ideas about the transmission of scientific knowledge in the Hellenistic period. He indicates that the most significant elements for the evaluation of this transmission are not the results at which different peoples arrived, but the methods they employed, and even more decisively the use of specific foreign terminology, signs, and symbols. Among the different elements that Hoffmann examines, he points out that mathematical astronomy originated in Mesopotamia, based on long records of planetary observations, which allowed for the calculation of the movement of the planets. This was registered in Egyptian planetary tables using the sexagesimal system, borrowed from Mesopotamia, since the normal Egyptian numerical notation uses a decimal base. Greek planetary tables also use the sexagesimal system, but the sign they employ for zero was not derived from cuneiform. Instead, it was borrowed from Demotic, ${ }^{85}$ which would indicate that the Babylonian calculation of planetary positions reached the Greeks by means of Egyptian documents. ${ }^{86}$ Another element borrowed from Mesopotamia was the zodiac, for which a series of symbols are used in the Demotic astronomical tables. ${ }^{87}$ Spiegelberg had already proposed that the origin of the symbols for the zodiac used in Byzantine manuscripts could be in these Demotic symbols, which Neugebauer confirmed for the sign for Libra. ${ }^{88}$ Jones has proposed the use of the Demotic sign for Aquarius in the Greek ephemeris P. Oxy. astron. $4184 .{ }^{89}$ Hoffmann considers this interpretation sound. ${ }^{90}$ An interesting point in this respect is that the Greek planetary tables always use abbreviations of the names of

[^22]the signs or the Greek letter corresponding to their number, but very rarely symbols, ${ }^{91}$ which indicates that the Demotic symbols were somehow transmitted through Late Antiquity into the Middle Ages, by means of planetary tables or of other sources that have not been preserved. ${ }^{92}$

The proposal that I make in the present work of the origin of the sign for first and last visibility in Greek papyri in the Egyptian sign for $p r$, used in P. Monts.Roca inv. 314 to indicate the first visibility of Mars, supports the idea that Greek astronomy incorporated the Babylonian calculation of planetary positions through the mediation of Demotic tables. ${ }^{93}$

Thus, as J. F. Quack has indicated, "Egypt should no longer be seen as a backwater, but as a hotbed of technological transfer. ${ }^{י 94}$ Monthly almanacs including the indication of longitudes in degrees and minutes and the notation of synodic phenomena have been considered as the most elaborate kind of almanacs, ${ }^{95}$ and thus their attestation also in Demotic in P. Monts.Roca inv. 314 shows that these complex tools were used in both Greek and Egyptian, probably by the same people in the same context. ${ }^{96}$

[^23]Table 1: Month numerals

| 2 | (Fr. $1+2+5+6+7$, col. $2, x+3)$ <br> (Fr. 1+2+5+6+7, col. 2, x+17) | 7 | (Fr. $1+2+5+6+7$, col. $2, x+9)$ |
| :---: | :---: | :---: | :---: |
| 3 | (Fr. $1+2+5+6+7$, col. $2, x+5)$ <br> (Fr. $1+2+5+6+7$, col. $2, x+18)$ | 8 | (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+10)$ |
| 4 | 10 y <br> (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+6$ ) <br> (Fr. 1+2+5+6+7, col. 2, x+19) | 9 | (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+11)$ |
| 5 | (Fr. $1+2+5+6+7$, col. $2, x+7)$ <br> (Fr. 1+2+5+6+7, col. 2, x+20) | 10 | $\therefore(\text { Fr. } 1+2+5+6+7, \text { col. } 2, x+12)$ |
| 6 | (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+8$ ) <br> (Fr. $1+2+5+6+7$, col. $2, x+21)$ | 11 | $\cdots \rightarrow$ (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+13)$ |

## Table 2: Day numerals

| $s w 1$ | (Fr. $1+2+5+6+7$, col. 2, $x+5$ ) <br> (Fr. $1+2+5+6+7$, col. $2, x+7)$ <br> (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+8$ ) | $\text { sw } 13$ <br> (?) | (Fr. 1+2+5+6+7, col. 2, x+18) |
| :---: | :---: | :---: | :---: |
|  | (Fr. $1+2+5+6+7$, col. $2, x+9$ ) <br> (Fr. 1+2+5+6+7, col. 2, x+19) <br> (Fr. $1+2+5+6+7$, col. $2, x+20)$ | $\text { sw } 15$ <br> (?) | $\ddot{n}-($ Fr. $1+2+5+6+7$, col. $2, x+16)$ |
| sw 3 | (Fr. 1+2+5+6+7, col. 1, x+19) <br> (Fr. $1+2+5+6+7$, col. $2, x+21)$ | $\begin{aligned} & \text { sw } 25 \\ & (?) \end{aligned}$ | (Fr. 1+2+5+6+7, col. 2, x+17) |
|  |  | sw 26 | 3 <br> (Fr. $1+2+5+6+7$, col. $2, x+4)$ |
| sw 6 | (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+6$ ) | sw 28 | (Fr. $1+2+5+6+7$, col. $2, x+10)$ |
| $\begin{aligned} & s w \\ & 10+\mathrm{x} \end{aligned}$ | (Fr. 1+2+5+6+7, col. 2, x+11) |  |  |
|  |  | $\begin{aligned} & \text { sw } 29 \\ & (?) \end{aligned}$ | (?) (Fr. $1+2+5+6+7$, col. $2, x+12)$ |

Table 3: Zodiac signs

| $\begin{aligned} & \text { ภ } \\ & \text { Leo } \end{aligned}$ |  | $m$ Scorpio |  |
| :---: | :---: | :---: | :---: |
| $\begin{aligned} & m p \\ & \text { Virgo } \end{aligned}$ | LT: (Fr. 1+2+5+6+7, col. 1, x+18)边橎 (Fr. $1+2+5+6+7$, col. 2, $x+18)$ ㄷ. to $($ Fr. $1+2+5+6+7$, col. $2, x+20)$ ${ }_{2} E_{2}$ (Fr. 1+2+5+6+7, col. 2, x+24) |  | (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+7$ ) <br> (Fr. $1+2+5+6+7$, col. $2, x+8)$ <br> (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+9$ ) <br> (Fr. 1+2+5+6+7, col. 2, x+10) |
| $\Omega$ <br> Libra | co <br> (Fr. $1+2+5+6+7$, col. $1, x+5)$ <br> $($ Fr. $1+2+5+6+7$, col. $1, x+19)$ <br> (Fr. $1+2+5+6+7$, col. $2, x+5$ ) <br> (Fr. $1+2+5+6+7$, col. 2, $x+21)$ <br> (Fr. $1+2+5+6+7$, col. $2, x+24)$ <br> $2 \pi$ <br> (Fr. $1+2+5+6+7$, col. 2, $x+11)$ <br> $\rightarrow$ is $\rightarrow \cdots$ <br> $($ Fr. $1+2+5+6+7$, col. $2, x+12)$ |  | (Fr. $1+2+5+6+7$, col. $1, x+7)$ |
|  |  | Vs Capricorn | (Fr. $1+2+5+6+7$, col. $1, x+8)$ |
|  |  | $\approx$ <br> Aquarius | sul\} $\overbrace{\mid(\text { Fr. } 1+2+5+6+7, \text { col. } 1, x+9)}$ |
|  |  | H <br> Pisces | (Fr. $1+2+5+6+7$, col. $1, x+10)$ <br> (Fr. 4, x+3) |
|  |  | $\uparrow$ Aries |  |
|  |  | $\gamma$ <br> Taurus |  |

Table 4: Longitude numbers

| 0 | (Fr. $1+2+5+6+7$, col. $1, x+5)$ | 7 | (Fr. $1+2+5+6+7$, col. $1, \mathrm{x}+21)$ (Fr. $1+2+5+6+7$, col. $2, x+9$ ) |
| :---: | :---: | :---: | :---: |
|  | (Fr. $1+2+5+6+7$, col. $1, x+6)$ <br> $($ Fr. $1+2+5+6+7$, col. $1, x+7)$ | 8 | (Fr. $1+2+5+6+7$, col. 1, $x+6$ ) <br> (Fr. 1+2+5+6+7, col. 2, x+19) |
|  | (Fr. $1+2+5+6+7$, col. $1, x+8)$ | 9 | 5! |
|  | -(Fr. $1+2+5+6+7$, col. $1, x+9)$ <br> (Fr. $1+2+5+6+7$, col. $1, \mathrm{x}+10)$ | 12 | (Fr. $1+2+5+6+7$, col. $1, \mathrm{x}+9)$ (Fr. 3, x+1) |
|  |  | $\begin{aligned} & 16 \\ & (?) \\ & \hline \end{aligned}$ | $\xi \rightarrow$ <br> (Fr. $1+2+5+6+7$, col. 2, $x+10)$ |
|  | $\text { - (Fr. } 1+2+5+6+7, \text { col. } 1, x+18)$ | 18 | (Fr. $1+2+5+6+7$, col. $1, x+10)$ |
|  | (?) $($ Fr. $1+2+5+6+7$, col. $1, x+19)$ | 19 | (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+20)$ |
|  |  | 20 | (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+4$ ) |
|  | $(\text { Fr. } 1+2+5+6+7, \text { col. } 2, x+4)$ | 20+x | $\int_{\text {(Fr. } 1+2+5+6+7, \text { col. } 2, \mathrm{x}+5)}$ |
|  | $($ Fr. $1+2+5+6+7$, col. $2, x+13)$ <br> $($ Fr. $1+2+5+6+7$, col. $2, x+18)$ | $\begin{aligned} & \hline 21 \\ & (?) \end{aligned}$ |  |
|  | $($ Fr. $1+2+5+6+7$, col. $2, x+19)$ | 26 | (Fr. $1+2+5+6+7$, col. $1, \mathrm{x}+18$ ) |
|  | $\operatorname{lin}_{1}(\text { Fr. 3, x+2) }$ | 50 | $\underline{-}(\text { Fr. } 1+2+5+6+7, \text { col. } 1, x+17)$ |
|  | (Fr. 4, x+3) <br> (?) $($ Fr. $4, x+4)$ | $50+\mathrm{x}$ | (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+4)$ |
| 1 | (Fr. $1+2+5+6+7$, col. $1, x+8)$ <br> (Fr. $1+2+5+6+7$, col. $1, x+19)$ | 52 | $($ Fr. $1+2+5+6+7$, col. $1, x+7)$ |
| 2 | (?) $($ Fr. $1+2+5+6+7$, col. $2, x+10)$ (Fr. 3, x+2) |  | $($ Fr. $1+2+5+6+7$, col. $2, x+11)$ |
|  |  | 56 | (Fr. $1+2+5+6+7$, col. $1, x+16)$ |
| 5 | $($ Fr. $1+2+5+6+7$, col. $1, x+5)$ <br> $($ Fr. $1+2+5+6+7$, col. $1, x+19)$ | $57$ <br> (?) | - $\mathrm{i}_{(\text {Fr. } 1+2+5+6+7, \text { col. } 2, \mathrm{x}+9)}$ |
| 6 | (Fr. $1+2+5+6+7$, col. $2, \mathrm{x}+8$ ) |  |  |

Table 5: Synodic phenomena

| Evening first $(\ldots h t p)$ | Fifo (Fr. $1+2+5+6+7$, col. 1, x+16) |
| :---: | :---: |
| First visibility (pr mh-l) |  |
| First station (ch؟ mh-l) | (Fr. 1+2+5+6+7, col. 2, x+22) |
| Acronychal rising (15.nt) | 4 (Fr. $1+2+5+6+7$, col. $2, x+10)$ |



Figure 1: Motion of Venus in year 4 of Vespasian, recomputed for Alexandrian and Egyptian dates, compared to the data in P. Monts.Roca inv. 314.
Sidereal frame of reference. Synodic events are indicated by their Greek letter symbols, and the points in P. Monts.Roca inv. are classified according to the character of the data: $\Delta=$ recomputed data; $\boldsymbol{\Delta}=$ recomputed data based on information preserved on the papyrus (either date or longitude); $\boldsymbol{\square}=$ both date and longitude preserved on the papyrus.


Figure 2: Motion of Jupiter in year 5 of Vespasian, recomputed for Alexandrian and Egyptian dates, compared to the data in P. Monts.Roca inv. 314.
For the meaning of the symbols used see the legend of fig. 1.


Figure 3: Motion of Mars in year 5 of Vespasian, recomputed for Alexandrian and Egyptian dates, compared to the data in P. Monts.Roca inv. 314.
For the meaning of the symbols used see the legend of fig. 1.

Fr. 3


Fr. 4


Fr. 7
Fr. 5

(zu Escolano-Poveda ,

Tafel 2

$$
\text { Col. } 2
$$

Col. 1

(zu Escolano-Poveda ,

Col. 2
Col. 1


Fr. 3


Fr. 4



[^0]:    1 The research on P. Monts.Roca inv. 314 is part of the DVCTVS Project (FFI2015-65511-C2-2-P) funded by the Spanish Ministry of Economy, Industry and Competitiveness, the goal of which is the conservation, cataloguing, study, and publication of the Spanish papyrological collections. I am greatly indebted to Sofía Torallas Tovar (University of Chicago) for offering me the study and publication of the Demotic papyri of the Abbey of Montserrat, and to the Abbey of Montserrat and Father Pius Ramón Tragan for granting me access to their papyrological collection. I am very grateful to my professors at the Johns Hopkins University, Betsy Bryan and Richard Jasnow, for their support and advice during the research and writing of this article, and especially to Richard Jasnow for reading several drafts of this paper and for his suggestions of readings and interpretations, which have been noted in the appropriate places in the text. I want to thank Johannes Thomann (Universität Zürich) for generously giving me his program PlanetSearch for the calculation of planetary positions, and for his encouraging comments on an early presentation of my research at the $28^{\text {th }}$ International Congress of Papyrology (Barcelona, August 1-6, 2016). I also would like to thank John Steele (Brown University) for reading a draft of this article and suggesting very useful references concerning Mesopotamian astronomy, and Alcyone Software's Planetary, Lunar, and Stellar Visibility for the computation of the visibility of the planets. I was kindly invited to present the results of this research at the conference "Scientific Traditions in the Ancient Mediterranean and Near East" (ISAW, September 19-20, 2019), for which I want to wholeheartedly thank the organizers, and particularly Alexander Jones (ISAW) for his insightful and encouraging comments. Thanks are due as well to the editors of Enchoria for their very pertinent comments, which have improved this article's clarity and thoroughness. Last but not least, I am very thankful to Mason Wilkes (Johns Hopkins University) for encouraging me in the last steps of my research and writing, and for very kindly reading several drafts of this paper and checking my English writing style.

[^1]:    2 Measurements of the fragments: Fr. $1,11.4 \times 5.5 \mathrm{~cm}$; Fr. $2,3.6 \times 1.8 \mathrm{~cm}$; Fr. $3,1.2 \times 1.6 \mathrm{~cm}$; Fr. $4,2.5 \times$ 0.6 cm ; Fr. 5, $2.1 \times 1.1 \mathrm{~cm}$; Fr. 6, $8.1 \times 1.4 \mathrm{~cm}$; Fr. $7,1.4 \times 1.5 \mathrm{~cm}$.

    3 I would like to thank Richard Jasnow for this reading. Although the name as such is not attested in the Demotisches Namenbuch or in Trismegistos People, its main component, $p 3-\underline{-} r d$, is attested as a personal name (s. v. p3-hrt "das (göttliche) Kind", $D N b 211$ ) and names formed with the pattern $p 3$-di- plus divine name are very common in Demotic (cf. DNb 280-343).
    4 A. Jones, A Classification of Astronomical Tables on Papyrus, in: N. M. Swerdlow (Ed.), Ancient Astronomy and Celestial Divination (Cambridge, MA 1999), pp. 299-340.

[^2]:    5 I would like to thank Kim Ryholt for bringing this papyrus to my attention, and for sending me high quality images of it.

[^3]:    6 F. Hoffmann, Astronomische und astrologische Kleinigkeiten V: Die Mondephemeride des P. Carlsberg 638, Enchoria 30 (2006/7), pp. 10-20.
    7 Hoffmann, Enchoria 30, pp. 11-13.
    8 Cf. O. Neugebauer / R. Parker, Egyptian Astronomical Texts, vol. 3, (Providence 1969), p. 219; P. Carlsberg 638, big fragment, $\mathrm{x}+2.4$ and $\mathrm{x}+2.5$, and small fragment, $\mathrm{x}+3$ and $\mathrm{x}+4$, cf. Hoffmann, Enchoria 30, p. 12.

[^4]:    9 Cf. Neugebauer / Parker, Egyptian Astronomical Texts, vol. 3, p. 218.
    ${ }^{10}$ Cf. Neugebauer / Parker, Egyptian Astronomical Texts, vol. 3, p. 218. Leo is not present in P. Carlsberg 638.
    ${ }^{11}$ Cf. Neugebauer / Parker, Egyptian Astronomical Texts, vol. 3, p. 218; CDD G (04:1): p. 1; W. Erichsen, Demotisches Glossar (Copenhagen 1954), p. 582.
    12 The five epagomenal days are normally called in Demotic hrw.w $5 n h b$ "five days of festival" or (hrw) 5 hry.w rnp.t " 5 (days) which are upon the year" (Wb. II, 430.3; CDD H (01.1): p. 79). In the Demotic planetary tables (P. Berlin 8279 and Stobart Tablets) the epagomenal days are introduced by the sign for $h b$ "festival," plus the number of the day. In the Stobart Tablets the sign for $h b$ is followed by a sun disk (cf. Neugebauer / Parker, Egyptian Astronomical Texts, vol. 3, p. 227; O. Neugebauer, Egyptian Planetary Texts, Transactions of the American Philosophical Society 32.2 (1942), p. 244).

[^5]:    ${ }^{13} C D D^{c}(03: 1):$ p． 122.
    14 ḥb hrw mh－15，$C D D$（10：1）：p．179；smt．t（？），$C D D S$（13：1）：p． 244.
    15 A．Jones，Astronomical Papyri from Oxyrhynchus，vol． 2 （Philadelphia 1999），pp．270－271．

[^6]:    16 Erichsen, Glossar, p. 711.

[^7]:    17 Erichsen, Glossar, p. 132.
    18 Erichsen, Glossar, p. 134; CDD P (10:1): p. 118.
    19 Cf. O. Neugebauer, Astronomical Cuneiform Texts, vol. 1 (New York 1983), p. 38; O. Neugebauer, Astronomical Cuneiform Texts, vol. 2 (New York 1983), pp. 475-476; and more recently H. HuNGER, Astronomical Diaries and Related Texts from Babylonia. Vol. 6: Goal Year Texts (Vienna 2006), p. x.
    20 Erichsen, Glossar, p. 135.
    21 Cf. Neugebauer, Transactions 32.2, p. 221.

[^8]:    22 Cf. NeUGEBAUER / PARKER, Egyptian Astronomical Texts, vol. 3, p. 218.
    ${ }^{23}$ Cf. Neugebauer / Parker, Egyptian Astronomical Texts, vol. 3, pp. 218, 252-254, and plate 80 C.
    24 In his edition of P. Carlsberg 638, F. Hoffmann points out that the use of this sign is mostly attested in the Ptolemaic period, referencing Glossar (Erichsen, Glossar, pp. 707-712). However, Roman period writings of the days of the month with this sign appear to be quite frequent as well (cf. Hoffmann, Enchoria 30, p. 11).
    25
    Hoffmann, Enchoria 30, plate 4.

[^9]:    ${ }^{26}$ Cf. Neugebauer / Parker, Egyptian Astronomical Texts, vol. 3, pp. 218-219.
    27 Cf. Neugebauer / Parker, Egyptian Astronomical Texts, vol. 3, p. 233.
    28 For the sign for zero, cf. section 6.
    ${ }^{29}$ Fr. $1+2+5+6+7$, col. $2, x+17$. The reading, however, is not clear.
    ${ }^{30}$ Fr. $1+2+5+6+7$, col. $2, x+9$. The reading is very tentative.
    31 Part of the name of this event may be $h t p$ for evening first, in line $\mathrm{x}+16$. For the reconstruction of the synodic events in this section, cf. Dating, reconstruction of the almanac, and provenance infra.

[^10]:    ${ }^{32}$ All these computations are using the Alexandrian calendar, for which cf. Dating, reconstruction of the almanac, and provenance infra.
    ${ }^{33}$ To calculate the visibility of the planets I have used Alcyone Software's Planetary, Lunar, and Stellar Visibility, available at www.alcyone.de/planetary_lunar_and_stellar_visibility.html. I have converted the tropical longitudes to the sidereal frame of reference employed by the tables of this period (cf. JoNes, $A s$ tronomical Papyri, vol. 1, p. 49) by adding a correction of $5^{\circ}$, obtained by means of the application of "Theon's formula," cf. A. Jones, Ancient Rejection and Adoption of Ptolemy's Frame of Reference for Longitudes, in: A. Jones (Ed.), Ptolemy in Perspective: Use and Criticism of his Work from Antiquity to the Nineteenth Century (New York 2010), pp. 11-44.
    I have obtained the data for the first and second stations through the simulator of the Almagest tables by R. vAN GENT at http://www.staff.science.uu.n1//gent0113/astro/almagestephemeris.htm, with sidereal longitudes.
    35 According to the recomputation of the data using the Almagest tables (cf. footnote 34), the sign entries in Sagittarius and Scorpio would have taken place in month 4 day 21 ( 17 Dec.) and month 10 day 22 ( 16 Jun.) respectively. However, P. Monts.Roca inv. 314 tends to be closer to the dates for sign entries in Stobart Tablet A obv. Therefore, I have opted for the dates recorded in the latter for this estimation of the number of lost entries. The difference in this case would only be an additional entry in month 4.
    36
    ${ }^{37}$ For this estimate I have used the data for sign entries in Stobart Tablet A obv. cols. II.21-III.5, excluding the entry for 1-I, which does not record a sign entry. I have compared this with the data for the visibility

[^11]:    of Mercury by means of the program Planetary, Lunar, and Stellar Visibility (cf. footnote 33) for year 4 of Vespasian (71/72 CE).
    38 W. A. Johnson, The Ancient Book, in: R.S. Bagnall (Ed.), The Oxford Handbook of Papyrology (Oxford 2009), p. 259.
    39 Jones, Astronomical Papyri, vol. 2, pp. 270-271.

[^12]:    40 NeUGEBAUER, Transactions 32.2; NeUGEBAUER / PARKER, Egyptian Astronomical Texts, vol. 3, pp. 228232, and plates 66-73. For the identification of P. Berlin 23547 as part of P. Berlin 8279 cf. F. Hoffmann, Astronomische und astrologische Kleinigkeiten III: P. Berlin P 23547, Enchoria 25 (1999), pp. 24-26.
    ${ }^{41}$ Cf. Commentary for this line supra.
    42 Evans, History and Practice of Ancient Astronomy, p. 314.

[^13]:    43 Neugebauer，Transactions 32．2，pp．229－230．
    ${ }^{44}$ For this recomputation I have used the simulator of the Almagest tables by van Gent（cf．footnote 34）， with a sidereal frame of reference．
    ${ }^{45}$ For the synodic events，except for the stations of the outer planets，I have used Alcyone Software＇s Plan－ etary，Lunar，and Stellar Visibility（cf．footnote 33）．I have estimated the stations by means of van Gent＇s simulator（cf．footnote 34）．
    ${ }^{46}$ Adding a correction of $5^{\circ}$ to convert the modern tropical longitudes to the sidereal frame of reference of the almanac（cf．footnote 33）．

[^14]:    ${ }^{47}$ For a discussion of the terminology used to indicate these synodic phenomena, cf. section 6.

[^15]:    48 Hoffmann, Enchoria 30, p. 20.
    49 Hoffmann, Enchoria 30, p. 11.
    50 Jones has pointed out that almanacs were produced a few decades after the dates they record (cf. A. Jones, The Place of Astronomy in Roman Egypt, Apeiron 27.4, p. 30).
    51 Jones, Astronomical Papyri, vol. 1, p. 58.
    52 Hoffmann, Enchoria 30, p. 10, note 3.

[^16]:    ${ }_{54}^{53}$ Col． $1, \mathrm{x}+16$ may be read as $h t p$ ，corresponding to its first evening visibility．
     fully spelled out，cf．e．g．P．Oxy．astron． 4199 recto 11．20，34，and verso 11．9，23，37；P．Oxy．astron． 4200 recto 1．6，and verso 1．3；P．Oxy．astron． 4201 col．i．2；P．Oxy．astron． 4202 col．iii．12，vii． 14 （JoNes，$A s$－ tronomical Papyri，vol．2，pp．268－283）．
    ${ }^{55}$ F．Ll．Griffith／H．Thompson，The demotic magical papyrus of London and Leiden，vol． 3 （London 1909），p．100，n． 1105.

[^17]:    ${ }_{57}^{56}$ M. Smith, The liturgy of opening the mouth for breathing (Oxford 1993), p. 123.
    57 M. Smith, Papyrus Harkness (MMA 31.9.7) (Oxford 2005), p. 210.
    58 Smith, Liturgy, p. 54; Smith, Harkness, p. 210.
    59 Technically, the acronychal rising is the last visible rising of the planet after sunset, and it takes place a few days before its actual opposition, which is not visible.
    ${ }^{60}$ For instances of $\dot{\alpha} \kappa \rho$ óvvðos "at nightfall" in Greek almanacs, cf. e.g. P. Oxy. astron. 4199 recto 1. 21, and verso ll. 11, 25, 40; P. Oxy. astron. 4200 recto 1. 8, and verso 1. 6; P. Oxy. astron. 4201 col. i. 3 (JONES, Astronomical Papyri, vol. 2, pp. 268-273).
    61 For a discussion of this terminology, cf. HuNGER, Astronomical Diaries, p. x. I would like to thank John Steele for this reference.
    62 I have not included Fr. $1+2+5+6+7$, col. $2, x+4, x+8, x+10$ and $x+17$ in table 4 due to their uncertain character.

[^18]:    63 Erichsen, Glossar, p. 25.
    ${ }^{64}$ F. Hoffmann, Astronomische und astrologische Kleinigkeiten IV: Ein Zeichen für "Null" im P. Carlsberg 32?, Enchoria 29 (2004/5), pp. 44-52; cf. also Jones, Astronomical Papyri, vol. 1, p. 62, fig. 16, for the shape of this sign in Greek astronomical papyri.
    O. NEUGEBAUER, On a special use of the sign "zero" in cuneiform astronomical texts, JAOS 61.4 (1941), pp. 213-215.
    66 R. LaBAT, Manuel d'épigraphie akkadienne (Paris 1995), p. 175.
    67 For a list of attestations of this use of zero in cuneiform texts up to 1955, cf. O. NEUGEBAUER, Astronomical Cuneiform Texts (New York/Heidelberg/Berlin 1983), p. 511, and p. 4 for a description of the tablets from Uruk and of the secondary use of the sign for zero as a criterion for the identification of the provenance.
    68 NeUgebauer, JAOS 61.4, p. 213.

[^19]:    ${ }^{69}$ This use only appears in one instance in the text, cf. Jones, Astronomical Papyri, vol. 1, p. 86, note 5. Other symbols are also used in some Greek papyri as separators between tens and units, such as a colonlike pair of dots in P. Cair.Mus. S. R. 3059 (part) line 8, and P. Colker iii 12 and 29, cf. S. D. A. AlSH / A. Jones, Another Greek Papyrus Concerning Babylonian Lunar Theory, ZPE 199 (2016), p. 133. In this commentary note Aish and Jones also indicate the use of a small raised circle in P. Oxy. astron. 4228 iii 3 , and point out that "It is tempting to trace the notation to an analogous practice found in Babylonian astronomical texts from Uruk, where the symbol employed was the same sign (GAM) that otherwise stood for zero as a sexagesimal place." I would like to thank Alexander Jones for this reference.
    ${ }^{70}$ Hoffmann, Enchoria 29, pp. 44-52.
    ${ }^{71}$ NeUGEBAUER, JAOS 61.4, pp. 214-215. He indicates that this practice is not directly related to the Mesopotamian use of the sign for zero. For a detailed analysis of the use of the "day" sign in the Stobart Tablets, cf. Neugebauer, Transactions 32.2, pp. 244-245.

[^20]:    72 No indications of last visibility have been preserved in P. Monts.Roca inv. 314. Nevertheless, the Greek astronomical papyri use the same sign for both first and last visibility, which according to my proposal here would derive in both cases from the Demotic notation for first visibility. For the use of the sign for both first and last visibility in a Greek almanac, cf. P. Oxy. astron. 4199; Jones, Astronomical Papyri, vol. 2, pp. 268-273. In P. Oxy. astron. 4203a, a monthly almanac for Mercury, the same sign is employed, duplicated, for first or last morning visibility, and duplicated with the loop filled in for first or last evening visibility (JONES, Astronomical Papyri, vol. 2, pp. 286-287). The sign, in any case, is the same.
    73 Jones, Astronomical Papyri, vol. 1, p. 215.
    74 JONES, Astronomical Papyri, vol. 1, p. 63.
    75 Erichsen, Glossar, p. 132.
    ${ }^{76} C D D P(10: 1)$, p. 57.
    77 Griffith / Thompson, Magical, vol. 3, p. 30, n. 298.
    ${ }^{78} C D D$ P (10:1), p. 119.

[^21]:    ${ }^{79}$ S. R. K. Glanville, The Instructions of 'Onchsheshonqy (British Museum Papyrus 10508) (Catalogue of Demotic Papyri in the British Museum 2; London 1955), pl. 24.
    ${ }^{80}$ Cf. Urk. I 110, 13 and 111,7. I would like to thank Friedhelm Hoffmann for this reference.
    ${ }^{81}$ For a summary of the earlier stages and trends in the study of Graeco-Egyptian astronomy cf. Jones, Apeiron 27.4. As a result of his study of the extensive Oxyrhynchus corpus of astronomical texts, Jones made a classification of the known astronomical papyri (cf. Jones, Astronomical Papyri, vol. 1, pp. 3547; Jones, in Ancient Astronomy, pp. 299-340).
    ${ }^{82}$ Cf. Jones, Apeiron 27.4, pp. 41-48, and especially 47-48: "the direction of flow may have been the other way, from Egyptian to Greek. For it was in Egypt, and not in Mesopotamia, that Greeks had the best exposure to the techniques of astral divination and predictive astronomy. In astronomy, then, as well as astrology, was Egypt the immediate source for many of the Babylonian elements in the Greek sciences?"
    83 JoNes, in Ancient Astronomy, p. 335.

[^22]:    ${ }^{84}$ F. Hoffmann, Internationale Wissenschaft im hellenistischen Ägypten, in: F. Hoffmann / K. S. Schmidt (Eds.), Orient und Okzident in hellenistischer Zeit - Beiträge zur Tagung "Orient und Okzident - Antagonismus oder Konstrukt? Machtstrukturen, Ideologien und Kulturtransfer in hellenistischer Zeit": Würzburg 10.-13. April 2008 (Vaterstetten 2014), pp. 77-112.
    85 This makes the demotic sign for zero the origin of the Arabic sexagesimal zero as well, cf. R. A. K IrANI, Arabic Numeral Forms, Centaurus 4.1(1955), pp. 1-12, esp. 11-12 and plates 8 and 9.
    ${ }_{87}^{86}$ Hoffmann, in Orient und Okzident, p. 84.
    ${ }^{87}$ Both Hoffmann and Von Lieven consider that the origin of these symbols is Egyptian (Hoffmann, Enchoria 29, p. 51, n. 47; A. von Lieven, Die dritte Reihe der Dekane oder Tradition und Innovation in der spätägyptischen Religion, Archiv für Religionsgeschichte 2.1 [2000], p. 26, n. 24). For an updated overview of the incorporation of the zodiac to Egypt, cf. J. F. QUACK, Egypt as an astronomical-astrological centre between Mesopotamia, Greece, and India, in: D. Brown (Ed.), The Interactions of Ancient Astral Science (Bremen 2018), pp. 81-85.
    88 O. Neugebauer, Demotic Horoscopes, JAOS 63.2 (1943), pp. 121-125.
    89 Jones, Astronomical Papyri, vol. 1, pp. 62, and vol. 2, 208-209.
    ${ }^{90}$ Cf. Hoffmann in Orient und Okzident, pp. 83-83: "Zweitens lassen sich die in griechischen Texten und über die weitere klassisch antike und die neuzeitliche Überlieferung bis heute gebräuchlichen Symbole für die Tierkreiszeichen paläographisch auf ägyptische Schriftzeichen zurückführen."

[^23]:    91 To the demotic sign in P. Oxy. astron. 4184, Jones adds the monograms in P. Oxy. astron. 4175 and P.S.I. inv. 75D, cf. JONES, Astronomical Papyri, vol. 1, p. 62.

    92 Hoffmann has noted the need of a more detailed analysis of the transmission of the Demotic symbols for the zodiac in Late Antiquity (Hoffmann, Enchoria 29, p. 51, n. 47). A caveat for this study will be the variety of symbols used in the Demotic tables themselves.
    93 It is interesting to note that the format of Greek and Demotic monthly almanacs is the same, cf. i. a. P. Oxy. astron. 4199 with P. Monts.Roca inv. 314.
    94 J. F. QUACK, On the Concomitancy of the Seemingly Incommensurable, or Why Egyptian Astral Tradition Needs to be Analyzed within Its Cultural Context, in: J. M. Steele (Ed.), The Circulation of Astronomical Knowledge in the Ancient World (Leiden/Boston 2016), p. 235. Updated state of the question in QUACK, Egypt as an astronomical-astrological centre, pp. 69-78.
    95 Jones, in Ancient Astronomy and Celestial Divination, p. 328.
    ${ }^{96}$ Cf. Quack, in Circulation, esp. pp. 231 and 238-239. For an updated discussion of all the known Demotic planetary tables, to which P. Monts.Roca inv. 314 should now be added, cf. also QUACK, Egypt as an astronomical-astrological centre, pp. 103-106.

