

Consideration of the Greek symbol ‘zero’

Raymond Mercier

raymond@almanach.co.uk

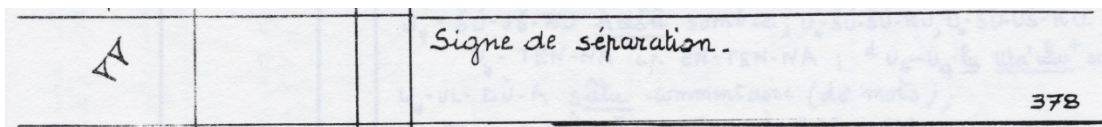
(formerly) RaymondM@compuserve.com

The Unicode Character Set has no codepoint for ‘zero’ among the Greek symbols. This symbol occurs notably whenever a sexagesimal notation is used in astronomical texts to record degrees, minutes and seconds, or hours minutes and seconds. In this proposal I present evidence from papyri, manuscripts and printed texts to show the various forms of this symbol, and I urge the acceptance of an agreed codepoint for it. This is important if editions of Greek astronomical texts are to be recorded satisfactorily in Unicode.

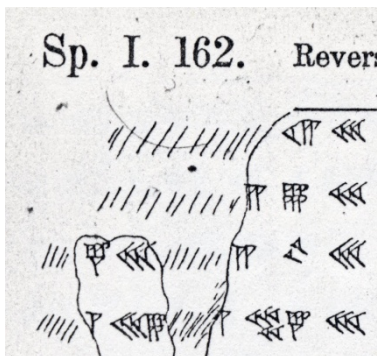
As will be clear from these notes zero appears in a variety of forms, with a marked change towards the end of the medieval period. Nevertheless it might be best to regard these as scribal variations, without any need to create a separate codepoint for the later forms.

CUNEIFORM TEXTS

In later Babylonian astronomical texts, of the Seleucid period, the zero in sexagesimal notation is marked by a separation symbol. This is listed in Labat’s *Manuel d’Épigraphie Akkadienne*,



This is found in astronomical texts, such as this, reproduced from Kugler’s *Babylonische Mondrechnung*, Tafel II, and its transcription, p. 34.



Zeile	F'			
1.	2 ⁰	12'	30''	'''
2.	2	6	30	
3.	2	0	30	
4.	1	54	30	

The zero, marked by a separation sign, is clear in the third row.

As Jones remarks in the passage quoted below, the cuneiform sign is more plausibly the source of the zero in the papyri, rather than from an abbreviation of οὐδέν

PAPYRI

Erik J.Knudtzon, O.Neugebauer, 'Zwei astronomische Texte', *Bulletin de la Société Royale de Lettres de Lund (Kungl. Humanistiska Vetenskapssamfundet i Lund)* 1946-7, 77-88, 2 Plates.

This is a study of an astronomical table in P. Lund 35a . The zero appears clearly in Tafel 1, in line 7 of col.vii : $\overset{\circ}{\text{---}}\overset{\circ}{\text{---}}$.



which is transcribed (p. 79) as

$\iota\varsigma$	ν	
δ	$\lambda\delta$	
$\iota\beta$	$\iota\zeta$	λ
ι	$\overset{\circ}{\text{---}}\overset{\circ}{\text{---}}$	ν

Georges Ifrah, *Histoire universelle de chiffres*, Paris : Robert Lafont, 1994.

In Vol. I, p. 375, we have an illustration of other forms of zero found in papyri.

PAPYRUS GRECS

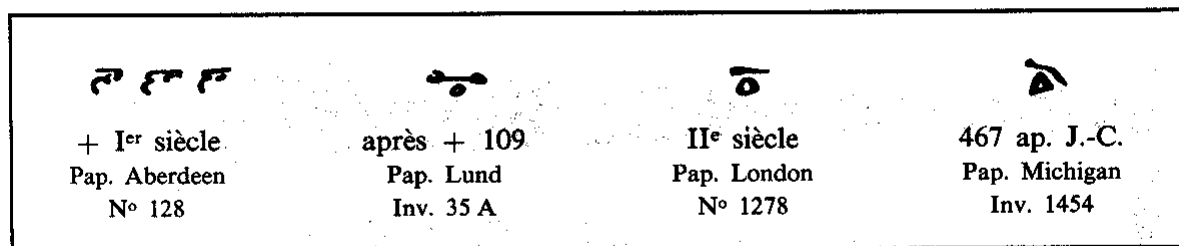



Fig. 13.74 A. – Le zéro « séxagimal » des astronomes grecs.

The form shown for Pap. London 1278 is more representative of that found in other astronomical papyri. That shown in Pap. Aberdeen 128 is clearly a cursive form, from which the ductus is clear, a line starting at the upper right, and ending with a half-drawn circle under the stroke.

A. Jones, *Astronomical Papyri from Oxyrhynchus (P. Oxy. 4133–4300a)*, American Philosophical Society, 1999.

p. 61:

The symbol for zero is a special case in that it probably does not stand in place of a specific word. It represents either an 'empty' place in a sexagesimal fraction or 'no whole units' (usually preceding a sexagesimal fraction). It was always closely tied to the sexagesimal notation, and only occurs in astronomical contexts. The most common form of zero in the papyri is a small circle with a horizontal stroke above it, but there are many variations (Fig. 16, below). The stroke is not the horizontal bar sometimes written above alphabetic numerals; the latter is never drawn above a zero, and is generally written further above the base line. I share Neugebauer's doubts of the supposition often repeated in paleographical handbooks that the symbol was an abbreviation of οὐδέν (Neugebauer [1957b] 14). It was the counter- part of the cuneiform

punctuation mark , which was used in the same way in sexagesimal numerals, and the direct ancestor of the zero of Arabic astronomical manuscripts (Irani [1955]). A Demotic counterpart is known only from P. Carlsberg 32, where the occurrences are unfortunately damaged so that it is not clear whether the horizontal stroke that can be seen was the entire symbol or only part of it.




















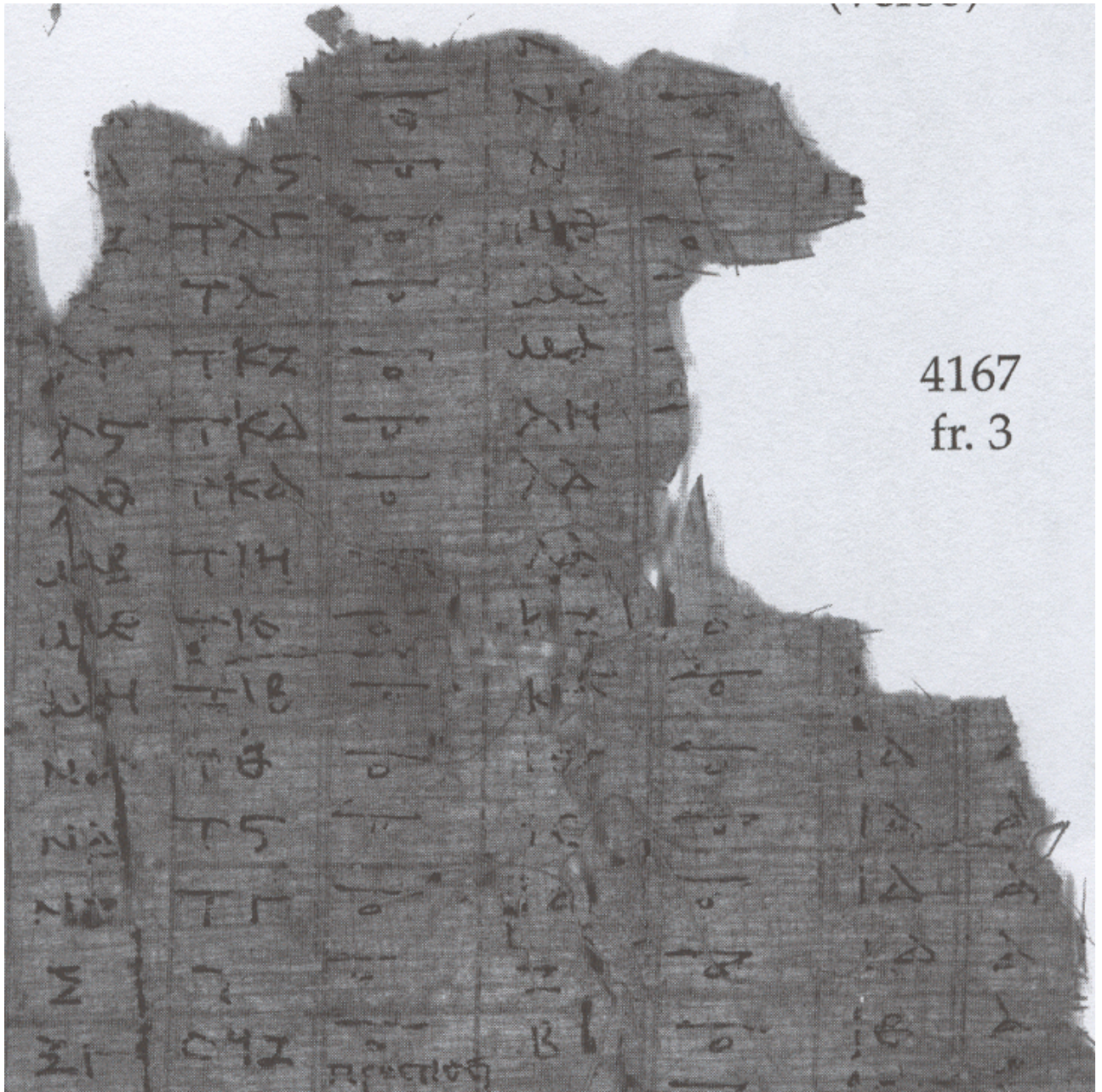
	4176 (A.D. 111), sim. P. Colker (I), 4134 (II), 4135 (II), 4136 (I), 4152, 4167 (III/IV), 4168 (IV), 4174, 4179 (A.D. 348), 4199 (II), 4201 (II), 4202 (II), 4205 (III), 4205a (III), 4220 fr. 3, P. Mich. 150, P. Mich. inv. 1454 (A.D. 467), PSI 1492, 1493, P. Lond. 1278, P. Ryl. 27		4165 (III/IV)
	4174a (II/III), sim. PSI 1491 (II)		P. Nelson (II), sim. P. Ryl. 526
	4156a (III)		4159a (II), sim. 4177 (A.D. 127), Dublin TCD F.7 (A.D. 100)
	4167 (III/IV)		4218, sim. P. Aberd. 128
	4167 (III/IV)		4223
	4173 (IV), sim. 4173a (IV), 4208 (IV), P. Ryl. 522 (III)		4177a (A.D. 245), sim. 4180 (A.D. 465)
	4148 (III), sim. 4162, 4163 (III), 4165a (III), 4166 (III), 4206 (III), 4220 fr. 1, 4221, P. Heid. inv. 34, P. Heid. inv. 4414 + P. Mich. 151		4138, sim. P. Berol. inv. 21226 (I), 21236
			4154 (III)
			4184a (A.D. 293)
			P. Lund 35a (II)
			4227
			P. Vind. gr. 29370 (A.D. 489)

Fig. 16. Forms of the zero symbol in astronomical papyri.

There are a great many tables in which the zero is shown. Of these there are eleven photographs in the Plates. This is a list of the papyri that are illustrated in the plates, together with the form of zero symbol used in each.

	Plate	line etc	zero
4136	II		∅
4138	XI	10	∅
4152	III	3,4	∅
4154	III	6	∅
4155	III	bottom	∅
4163	IV	bottom	∅
4165	VI	col.iii, etc	∅
4167 fr.3	V	col.v	∅
4174a	VI	col.i line 1	—○—
4203a	X		∅
4205	V	col.i, bottom	∅

The photo of 4167 in Plate V is reasonably clear, with many examples of zero.



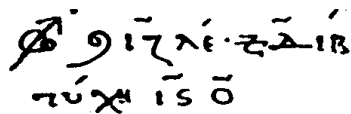
The zero shown here is quite typical of all the papyri shown in the Plates, with the curious exception of P4174a, where it appears as o, with the line drawn under the small o.

MANUSCRIPTS

Fifth century

O. Neugebauer and H.B. van Hoesen, *Greek Horoscopes*, American Philosophical Society, 1959; pp. 152-157, 188.

The examples in this volume are taken from a variety of sources, epigraphs, papyri, and manuscripts. Among the manuscripts there is a clear example in the horoscope L.497. This is dateable to A.D. 497, and is found in three manuscripts Vienna, Cod. phil. gr. 179; Modena, Cod. 85; Florence, Laur 28/34. The zero is found in the line



Transcription:

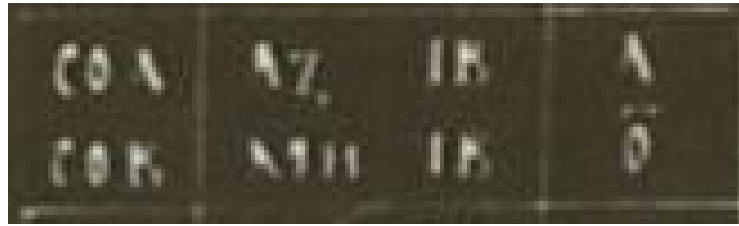
♁ ῑ ζ λ̄ ε · ς δ̄ ιβ̄
τ̄ ῡ χ̄ η̄ ῑ ζ̄ ο̄

Mars Leo 17;35, Jupiter 4;12
Lot 16;0

Here the bar over the zero is rather shorter than in the papyri, so the result is much the same as omicron + macron.

Ninth century

In ninth century Byzantine manuscripts the character for zero differs little from the papyri. For example in Vat gr 1291 fol.31,



ΣΟΑ	ΛΖ	ΙΒ	Α
ΣΟΒ	ΜΗ	ΙΒ	Ō

Here the zero consists of a full size uncial omicron with a macron.

Florence Laur 28/26 (ca 886-912) fol. 121.

Uncial script.



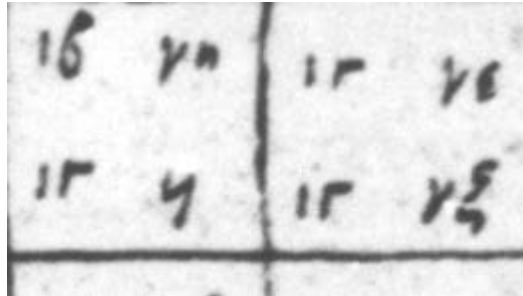
The last two lines read:

□	Η	□	ΙΒ
Β	□	Α	ΚΣ

Here the zero shows a closer resemblance to that in the papyri than to the zero in the contemporary manuscript Vat gr 1291 shown above.

Fourteenth century

In the some late medieval manuscripts the form of the symbol has altered considerably. For example, from a fourteenth century Byzantine manuscript (Escorial Σ -I-11, fol.53r), a copy of the Persian Syntaxis. For zero we have a character that might have arisen from a very cursive handling of the older \bar{o} , or ρ , but is nevertheless quite different from it.



which reads

12;58	13;55
13;0	13;57

Here the zero is quite similar to the Coptic Ϡ (U+03E5); of course it is not suggested that there is any historical connection with the Coptic character.

Fifteenth century

Manuscript of the Astronomical Manual of Gemistos Plethon

Vienna phil gr 140, fol.90

ρμξ	σϛ	ϛ	10	ϛ	μθ	μ
ρμ	σϛ	ϛ	16	ϛ	λϛ	μ
ρμϛ	σϛ	ϛ	ε	ϛ	λϛ	μ
ρμϛ	σϛ	ϛ	μϛ	ϛ	λθ	μ
ρϛθ	σϛ	ϛ	μϛ	ϛ	μϛ	λ
ρϛϛ	ρϛϛ	ϛ	μϛ	ϛ	λϛ	λ
ρϛϛ	ρϛϛ	ϛ	λϛ	ϛ	λϛ	λ
ρϛϛ	ρϛϛ	ϛ	λϛ	ϛ	λϛ	λ
ρϛϛ	ρϛϛ	ϛ	μϛ	ϛ	10	μ
ρϛϛ	ρϛϛ	ϛ	16	ϛ	μϛ	μ
ρϛϛ	ρϛϛ	ϛ	ϛ	ϛ	λϛ	μ
ρϛϛ	ρϛϛ	ϛ	ϛ	ϛ	λϛ	μ

The zero appears repeatedly in the central column. This is a small circle surmounted by a line, of such a size that the whole no larger than other Greek characters, that is smaller than omicron + macron.

Twelfth century Arabic
Manuscript of the Zīj al-Sanjārī

Private possession, sold by Quaritch (London), fol.141r.



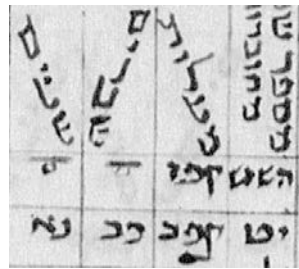
١	□	له
٢	١	□
٣	١	لا
٤	٢	٢

The zero symbol clearly follows the Greek papyri.

Twelfth century Hebrew

Manuscript of the Tables of Abraham bar Hiyya

Paris Bibliothèque Nationale fonds hébreu 1046 fol. 12



שניים	שברים	מעלות	מספר שנים מחונרות
□	□	קפז	השרש
נא	כב	קפב	יט

seconds	minutes	degrees	Number of collected years
0	0	187	Root
51	22	182	19

The zero is follows the common Greek form.

See Raymond Mercier, 'Astronomical tables of Abraham Bar Hiyya', in Stern (2014)

Twelfth century Latin

Latin version of the Tables associated with Abraham bar Hiyya
Cambridge UL Hh.6.8 Vol. 1 fol. 13v

Table of mean motion of Saturn for 1370 Feb 28, 1390 Feb 28



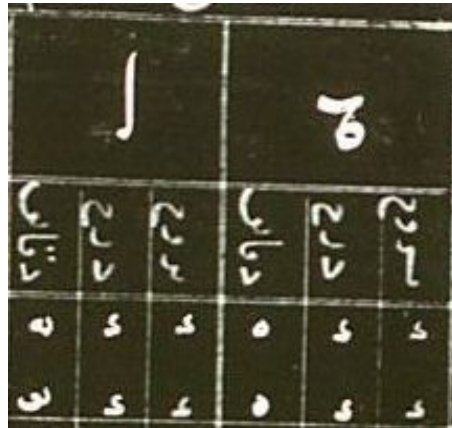
year	sign	degrees	min	sec
1369	8	20	52	41
1389	4	25	30	40

Two quite different forms of zero are found in successive rows !

See Raymond Mercier, 'Astronomical tables of Abraham Bar Hiyya', in Stern (2014)

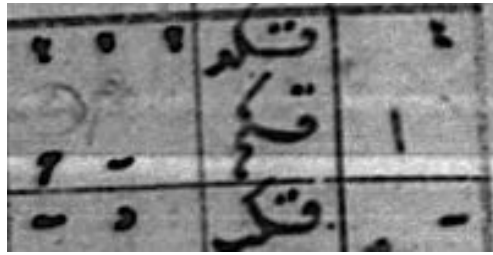
Twelfth century Arabic
Manuscript of the Zīj al-Sanjārī

Vatican Library, Vat. ar. 761 fol.168.



The first row shows an exceptionally clear example of the zero.

Thirteenth century Persian
 Manuscript of the Zīj-i Īlkhānī
 Cambridge University Library, Browne O.2.7, fol.9r



۴ ۴ ۴	قکد	۴
ح ب [۴]	قکج	۱
د [۴] ب	قکب	ب

The zero symbol is clearly a cursive development from the regular circle with the macron. This form is found almost unchanged in the Persian Syntaxis noted above, which is in fact a Greek version of the Zīj-i Īlkhānī.

PRINTED EDITIONS

J.L.Heiberg, *Claudii Ptolemaei, Opera Astronomica Minora*, Leipzig: Teubner, 1907.

In the Greek texts edited here Heiberg has used symbols for the Greek zero that vary from one text to another.

p.78

7 ὁμοίως δὲ καὶ ὁ μὲν τοῦ Ἑρμοῦ ἀστὴρ ἐν ἔτεσιν ἡλιακοῖς τοῖς πρὸς τὰ ἀπόγεια καὶ τὴν τῶν ἀπλανῶν σφαῖραν μεταλαμβανομένοις $\overline{\Delta\gamma}^{ov}$, ἃ ἐστὶν Αἰγυπτιακὰ $\overline{\Delta\gamma}$ καὶ νυχθήμερα $\overline{\sigma\nu\epsilon}$ ο $\overline{\nu\delta}$ $\overline{\mu\varsigma}$ $\overline{\nu\alpha}$ ἔγγιστα,

In this edition of the Planetary Hypotheses, Heiberg, in the last line, has used a simple circle is used to represent zero. It is the same size as the Greek characters.

p.150

τοῦ ὀμαλοῦ νυχθήμερον μέσα κινήματα, οἷων ὁ τροπικὸς $\overline{\tau\xi}$,
15 ἀπλανῶν σφαίρας $\overline{\omicron}$ $\overline{\omicron}$ $\overline{\omicron}$ $\overline{\epsilon}$ $\overline{\nu\epsilon}$ $\overline{\delta}$ $\overline{\xi}$
Κρόνου ἐπικύκλου. $\overline{\omicron}$ $\overline{\beta}$ $\overline{\omicron}$ $\overline{\lambda\gamma}$ $\overline{\lambda\alpha}$ $\overline{\kappa\eta}$ $\overline{\nu\alpha}$

Through the edition of this text, Inscriptio Canobi, Heiberg has used an omicron together with an accent sometimes called Vrachy.

p.169

ἐκάστου τὸ ἀπόγειον ἀπέχει τοῦ ἀπλανοῦς, τουτέστιν 10 ἐπὶ μὲν Κρόνου μοίρας $\overline{\rho\iota}$ $\overline{\lambda}$, ἐπὶ δὲ Διὸς $\overline{\lambda\eta}$ $\overline{\lambda}$, ἐπὶ δὲ Ἄρεως $\overline{\tau\nu\gamma}$ 0, ἐπὶ δὲ Ἀφροδίτης $\overline{\sigma\alpha\beta}$ $\overline{\lambda}$, ἐπὶ δὲ Ἑρμοῦ $\overline{\xi\xi}$ $\overline{\lambda}$, τὸν συναχθέντα ἀριθμὸν ἐξ ἀμφοτέρων

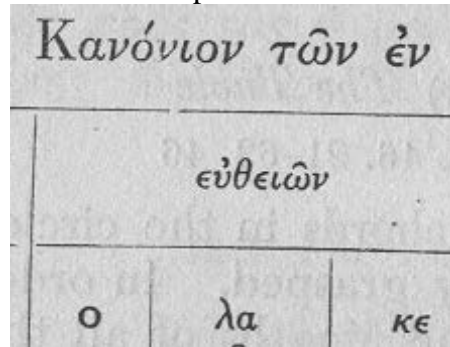
In this edition of the Handy Tables Heiberg has used an ordinary Latin number zero.

Ivor Thomas, *Greek Mathematics*, volume II, Loeb Classical Library, London & Cambridge Mass., 1951.

In this volume zero is found in extracts from Ptolemy's *Syntaxis*, where it is printed as a circle, slightly distinct from omicron.

Compare this zero with lower case omicron in the table on page 444.

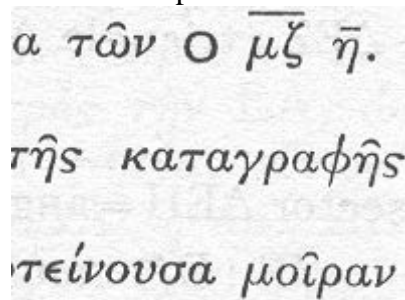
p. 444



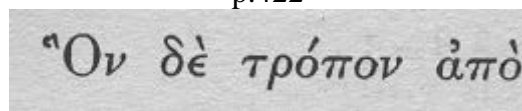
The number is 0;31,25. written in the way that is now commonplace for sexagesimal numbers.

Elsewhere a larger circle is used for zero, which may be compared with the upper case omicron (p.422)

p.440



p.422



These show that although the editor has not been entirely consistent in the form of zero, he has always used a character differing from the lower and upper case omicron. On the other hand the Latin letter O in Arial font, is very close to this 'zero'. The number is 0;47,8.

Georges Ifrah, *Histoire universelle de chiffres*, Paris : Robert Lafont, 1994.

A. Jones, *Astronomical Papyri from Oxyrhynchus (P. Oxy. 4133–4300a)*, American Philosophical Society, 1999.

Erik J. Knudtzon, O. Neugebauer, 'Zwei astronomische Texte', *Bulletin de la Société Royale de Lettres de Lund (Kungl. Humanistiska Vetenskapssamfundet i Lund)* 1946-7, 77-88, 2 Plates.

F. X. Kugler, *Babylonische Mondrechnung*, Freiburg im Breisgau, 1900.

R. Labat, *Manuel d'Épigraphie Akkadienne*, Paris, 1948.

Sacha Stern and Charles Burnett, *Time, Astronomy, and Calendars in the Jewish Tradition*, Brill 2014.

Ivor Thomas, *Greek Mathematics*, volume II, Loeb Classical Library, London & Cambridge Mass., 1951.