

Arabic, *Rūmī*, Coptic, or merely Greek Alphanumeric Notation? The Case of a Mozarabic 10th Century Andalusī Manuscript

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I. Introduction

The aim of this paper is to analyse the notation that appears alongside the Roman numerals in the Latin manuscript MDU-604 of the Capitular Library in Urgell (Northern Catalonia, Spain)¹, which was copied in 938. Until now, this notation (see Table II and Fig. 1) has been considered to be the oldest testimony of Hindu-Arabic ciphers in the Iberian Peninsula². However, an examination of the entire manuscript, featuring at least two

¹ The See of the Diocese of Urgell is attested at least since the 6th century.

² Pujol i Tubau [1917: 12-14] seems not to recognize the somewhat distorted Greek letters in the manuscript as ciphers, judging by his transcription of folio 19v. Mundó [1994: 140 & 1998: 514-515] interprets the Greek alphanumeric figures written next to the Roman numbers (see table II) as unrelated Arabic ciphers and, hence, considers them to be the oldest testimony of Hindu-Arabic figures in the Iberian Peninsula. This opinion is shared, among others, by Alturo i Perucho [2003: 124]. Nevertheless, the Greek alphanumeric ciphers agree in all cases (except for 3 errors in a total of more than 150 correspondences) with Roman figures. Confusion between Hindu-Arabic and Greek (or *rūmī*) figures is not uncommon. Just as a sample, Menéndez Pidal [1959: fig 3] did not recognize as Greek notation the ciphers in manuscript El Escorial R.II.18, which are extremely similar to the ones in the Urgell manuscript. Also, Kunitzsch [2003: 5, n.14], quoting a personal letter from W. Diem, mentions a papyrus in which the date, considered at one time to be written in Hindu numerals, seems rather to be formed by (cursive) Greek numeral letters.

complete series of alphanumerical signs, one of them covering a complete range of ciphers from 1 to 101, proves that the figures belong to an alphanumerical system, which could be the oldest surviving evidence in the Iberian Peninsula of *rūmī*³, Coptic, or merely Greek alphanumerical notation, but is definitely not Hindu-Arabic. Through a comparative analysis of all these figures and of the illuminated initials in the manuscript, as well as of their respective historical, geographical and chronological contexts, I will try to determine the nature of the notation used in this manuscript.

I.1. Greek alphanumerical notation and its derivates

Perhaps it would be useful to start with a general overview of these alphanumerical notations.

As early as the 3rd century BC the alphanumerical notation was in full use in Greece. This system of notation – in which the letters of the alphabet are assigned a numerical value – was adapted from the Phoenician Northern Semitic alphabet, which had been introduced in Greece probably some time between the 10th and the 8th century BC.

For the alphanumerical notation the Greeks used the following series composed by 27 signs and distributed as follows:

Units: $\alpha = 1$, $\beta = 2$, $\gamma = 3$, $\delta = 4$, $\varepsilon = 5$, $\zeta = 6$ ⁴, $\zeta = 7$, $\eta = 8$, $\theta = 9$;

³ *Rūmī*, *zimāmī* and *fāsī* ciphers are conventionally called *rūmī*. This range of names covers the development in the Maghrib of a decimal non-positional system of 27 symbols sharing a single ultimate Greek origin. These ciphers, attested by González Palencia [1926-1930: vol. I, 48] in notarial documents from the end of the 12th century in al-Andalus, were also used throughout a large area of the Maghrib, for administrative, commercial and notarial purposes, over a long period, which lasted until the 19th century. *Rūmī* ciphers are documented in the Maghrib as early as the 12th century, by Abū Bakr al-Haṣṣar, in his *Kitāb al-kāmil*. Later, Ibn al-Bannā' (13th-14th c.) dedicated several epistles to the *Hisāb al-zimām* also calling these ciphers *al-rūmī*. Ibn Qunfudh (14th-15th c.) presents *zimāmī* ciphers together with *ghubārī*, but recommends the use of *ghubārī* figures to perform arithmetical operations. It seems that *rūmī* ciphers suffered many transformations before becoming *al-qalam al-fāsī* or *fāsī*. Cf. Lamrabet [1994: 179, num. 330, 382 & 425]; Guergour [2000: 67-74] and Aballagh [2002].

⁴ Ancient *digamma* (old Semitic *waw*) appears, as a numeral, in the ancient papyri, with the forms *f* or *C*. Further developments lead to the form ζ , called *stigma*, which is

Tens: $\iota = 10$, $\kappa = 20$, $\lambda = 30$, $\mu = 40$, $\nu = 50$, $\xi = 60$, $\o = 70$, $\pi = 80$, $\psi^5 = 90$;

Hundreds: $\rho = 100$, $\sigma = 200$, $\tau = 300$, $\upsilon = 400$, $\phi = 500$, $\chi = 600$, $\psi = 700$, $\omega = 800$, \beth (ancient *sampi*, old Semitic *sadé*) = 900.

Intermediate figures were represented by simple addition from left to right for instance, from 11 to 19: *iota* (ten) plus *alpha*, *beta*, etc. (units), as can be seen for numbers 15 and 16 in Fig. 1.

This system included at the beginning the three Phoenician alphabetical signs: *digamma*, *koppa* and *sampi*, which were not used in normal Greek writing.

To distinguish between ordinary letters and numerals, a small stroke was, in general, written above them. We find this system in the majority of Greek manuscripts from the 3rd century BC onwards, either in literary papyri⁶ or, later, in Patristic manuscripts, indicating above all *capitula* and titles⁷.

The Coptic script, which replaced the Demotic at the last stage of Egyptian language, borrowed the alphabet and alphanumerical system from the Greeks about the 2nd century BC. Christians started to use it around the 2nd century AD and some two centuries later it became the language of the monastic communities. It seems that during these first centuries a range of geographically dependent dialects of Coptic developed, of which the two most important were *Sahidic* and *Bohairic*. Between the 4th and 9th centuries AD, *Sahidic* was the standard literary language, while *Bohairic*, documented in the 4th century, became the official language of the Church during the 9th century. This fact has a bearing on the present survey; whereas in *Sahidic* script the numerals are

found already in 862 AD. After the emergence of the minuscule alphabet three forms coexist: **Τ**, **Ϲ**, **Ҫ**. Cf. Gardthausen [1913: 366-367].

⁵ The sign ψ , ancient *koppa* (old Semitic *qof*), is attested only in coins. In manuscripts and in some coins it is written with the symbol: \beth (a rho open at the top and pointing to left), which later developed into the more stylized form: \beth . Cf. Gardthausen [1913: 368].

⁶ The Greek papyri found in Egypt have constituted the basic material for the study of Greek writing from the 4th century BC to the 8th century AD.

⁷ Cf., for instance, Martin - Vezin [1990: 123-136].

usually written in full and the system based on the Greek model is used only rarely, in *Bohairic* script the Greek system is very common.

On invading Egypt, the Arabs delegated administration and public accounting to the Copts, because of the latter's experience as functionaries during the centuries of Byzantine rule. At that time, Egyptian, written by means of the Coptic alphabet, was the vernacular language and Greek was used mainly in the administration and in higher education. Scholars and functionaries were mostly bilingual, their mastery of Egyptian and Greek being roughly equal⁸.

When Arabic began to be widely used alongside Coptic, it became customary to write the numbers in Arabic texts either in words or using the Greek alphanumerical notation⁹, which probably reached the Arabs directly through Coptic functionaries who used Greek, rather than through the Coptic language itself, since, as stated above, between the arrival of the Arabs and the 9th century, the most widespread dialect was *Sahidic*, which seldom used the alphanumerical system. I have in mind accounting documents such as the papyrus written in Arabic in the 9th century, containing data expressed in Greek alphanumerical notation¹⁰. However, liturgical and religious writings, such as a 9th century Arabic manuscript containing a translation of the Gospels, in which the verses are numbered with Greek alphanumerical notation¹¹, seem to show the influence of *Bohairic* Coptic. We also know of Egyptian manuscripts in which the quires are numbered with Coptic alphanumerical notation¹².

This shows two probable sources for the Greek alphanumerical notation used in Egypt, during the early centuries of Arab domination:

1. Greek notation, employed for administrative purposes, and
2. Coptic notation, used in religious writings, although we should not forget that the Copts continued to acquire and copy Greek manuscripts,

⁸ For information on the subjects taught in Coptic schools, cf. Hasitzka [1990: 15-16]

⁹ Later on, the Arabs created the *abjad*, their own alphanumerical system, based on the Greek, the Hebrew, and the Syrian alphanumerical notations.

¹⁰ Egyptian National Library, inv. nr. 283.

¹¹ Vatican Library, Arabic Borghesian Codex 95, fol. 173.

¹² As reported by King [2001: p. 73].

especially liturgical and religious texts, and, therefore, the influence of Greek script never died out.

II. The manuscript

Urgell Capitulary Library, in existence since at least 1059, owned 170 titles in 1147¹³, including the manuscript MDU-604. This manuscript contains part of Gregory the Great's *Dialogi*¹⁴, and the *Geronticon*, or *Vitae Patrum*¹⁵, as well as other patristic texts and was copied in al-Andalus in 938 as mentioned in the *subscriptio*.

II. 1. The alphanumerical notation in the Urgell manuscript

The alphanumerical notation under consideration (Tables I and II, Fig. 1)¹⁶, alongside Roman numerals, is used to number the quires¹⁷ of the manuscript, as well as the *capitula*, serving to facilitate access to the text, although in the corresponding indexes the *capitula* are numbered only by means of Roman figures, with few exceptions¹⁸.

¹³ Ten codices are documented in Urgell cathedral in 839, cf. Baraut [1992: 54].

¹⁴ End of book I, of which the three initial quaternions were lost probably before the last binding, and all of book II. As for book III, we have little more than the index of the *capitula*, and the first folio of chapter I, since, between folios 48v and 49r of the modern foliation, part of its quire 1, all quires 2, 3, 4, 5, 6, 7 and part of quire 8 are missing.

¹⁵ In addition, between folios 48v and 49r a folio was cut before modern Arabic foliation, where there was possibly the explicit and subscription of book III and the incipit of the *Geronticon*. Very often miscellaneous manuscripts dealing with Greek Patristic (Ancient Church Fathers) are entitled *Liber Geronticus*.

¹⁶ Appearing especially in the *Dialogi* and the *Geronticon* and exceptionally in the rest of the manuscript.

¹⁷ All of them, at least those that remain, are quaternions.

¹⁸ See, for instance, chapters I, II and CI in the index appearing in folios 139r and 139v which show both Greek and Roman notation.

The Roman numerals indicating the *capitula* in the Urgell manuscript are partially enclosed by a capitular gamma (Table II), a feature that we find especially in the oldest Bible and Gospel manuscripts¹⁹.

In the *capitula* and rubrics in general, the alphanumerical notation appears to have been written after the rest of the text. This phenomenon can be seen on folios 8v, 15r, 21v, 24r, 26r, 27r, 28r, 30r, 36r, 41r, 42r, etc. (to mention only the first ones) where we find the alphanumerical figures in the margins. Roman numbers also seem to have been added once the text had been already written, as shown, for instance, on folios 12r (XXXVIII), 15r, 27r, 36r, 42r, etc.

As far as the quire notation is concerned, Roman figures are written in the last leaf of each quaternion, in the middle of the lower margin of the verso²⁰, followed by the abbreviation *q'* indicating *quaternio*²¹, while alphanumerical notation is written in a paler ink and to the left of the Roman figures²². Hence, the Urgell manuscript does not reflect the pure Latin tradition, since in Latin manuscripts quires were, as a rule, marked by means of Roman numerals alone²³. On the other hand, Greek ciphers

¹⁹ Cf. Stienon [1991: 250-251] and Martin - Vezin [1990: 73-111].

²⁰ A feature alien to Latin manuscripts.

²¹ Cf. Bischoff [1985: 30]: "Les cahiers sont numérotés. Dans les manuscrits latins d'origine orientale (Byzance), suivant l'usage grec,... soit par des chiffres..." and Lowe [1972c: 202]: "The Roman numeral (in ancient Latin mss.) is, as a rule, preceded by the letter *q*, standing per quaternio, the abbreviation being indicated either by an oblique stroke through the shaft of the *q*, or a horizontal stroke over it, or by a mere dot after it" (this last sign is the one that appears in the Urgell manuscript MDU-604).

²² In the oldest Latin manuscripts, quire marks are generally found "in the lower corner of the final page of the gathering", as per Lowe [1972c: 202].

²³ From a list of almost fifty old Latin manuscripts and fragments collected by Lowe [1972c: 188-195], indicating palaeographical data, only one item (a fragment of a Justinianus Codex of Greek tradition) has quires marked by "Roman and Greek numerals", while sixteen items have only Roman numerals, nine items bear no indication, being fragmentary, in three items quire marks are mentioned as "numerals" without further specification and one has quires marked "by letters". Double notation for quire marks, apart from Greek-Roman numerals, is shown also in Syrian manuscripts, as the one kept in the British Museum (Ad. 14.603), dated probably 7th or 8th century AD, whose gatherings are numbered with Syrian alphanumerical notation together with ciphers of the old numbering system.

were used in Greek ambits, as we can see in the Greek manuscripts copied in the Italian Peninsula, reproduced by A. Grabar²⁴, and also in the Greek Patristic tradition²⁵.

In general, the alphanumerical notation used in the chapters and quires of this manuscript could have been written as a reminder before writing the Roman numerals, perhaps because the scribe, undoubtedly Mozarab, was copying from a manuscript with Greek alphanumerical notation and doubted whether it would be understood by abbess Gundissa²⁶, for whom the manuscript was copied (and who, so far, remains unidentified). As for the quires, they may have been numbered with the Greek alphanumerical notation also as a guide for the binder.

So, this alphanumerical notation may also show that the copyist, and perhaps the binder, could have been familiar with Greek ciphers, either already known in the Byzantine milieux of the Iberian Peninsula, or brought by the Arabs through Greek or Coptic alphanumerical notation. Interestingly, the date mentioned in the *subscriptio*²⁷, though written using Roman numerals, is indicated not only by means of the Hispanic era and the characteristic Roman method of dating²⁸ – weekday (*feria*), time of day (*ora*) and day of the month (*kalendas* in this case) – but also by the

²⁴ In the manuscripts reproduced in Grabar [1972], the notation in figs. 4, 46, 48, 64, 66, 85, 131, 171-182 & 185-195 is written in Greek uncial or half uncial script, while the notation corresponding to figs. 164 & 232-255 is written in Greek minuscule depending on the handwriting used in each manuscript, although always with an upper trait. Cf. also Bischoff [1985: 194-195] and Thompson [1940: 119]. In the Urgell manuscript they are written in Greek minuscule and without upper trait, perhaps because there was no need to differentiate them from the letters, since the text was written in Latin. Nevertheless, a comprehensive study of numerals appearing in Greek and Latin manuscripts is needed to determine, after establishing the date and place of the copy, which kinds of manuscripts carry Greek alphanumerical ciphers. This would help us to make a more precise comparison with the Urgell manuscript.

²⁵ Martin - Vezin [1990: 123-136]

²⁶ For other cases of double notation, see Tannery [1920: 202].

²⁷ In the *Geronticon*, since the last page of the *Dialogi* is missing and we do not know whether there was a subscription there.

²⁸ Indication of the day, time of the day and month was also a practice used in Arabic colophons.

years of the reign of ^cAbd al-Rahmān (III) and the *luna* (Arabic month)²⁹. Also the Arabic gloss³⁰ in folio 155r reflects an Arabic milieu.

Further evidence of a possible Arabic influence is found in the *Ovetensis* manuscript (miscellaneous from Oviedo, now in Biblioteca de El Escorial R.II.18), dated probably in the 9th century³¹. Folio 55r (Fig. 2) shows an alphanumerical notation very similar to the one in the Urgell manuscript (Fig. 1). It is interesting that, while in the Urgell manuscript the Greek or Coptic notation appears in a purely Latin context, in the Escorial manuscript this notation appears in an Arabic context, i.e. a marginal note in Arabic, belonging to a short treatise on land-surveying, showing an addition of distances in years, months and days.

G. Menéndez Pidal³² dates the manuscript in the 9th century and states that the document shows “los más viejos numerales y el más viejo cero de occidente”³³, although the two dots in line 3 of the days column do not represent a zero but merely a mark of an empty entry in the column, as already noticed by A. Labarta and C. Barceló³⁴. According to G.

²⁹ The subscription reads as follows: *Explicit Liber Ieronticon deo gratias. Ego Isidorus pr(e)sb(i)t(er) humillimus qui hu(n)c liber scripsi (sic) usque ad finem preveni (sic) per petitionem Gundise abbatisse. Sub era dccccclxxviii, die ii f(eri)a, ora iiiia, iiiii k(a)l(en)d(a)s n(ovem)br(i)s, regnante Habdirrahmen, filio Muhammed, nepos Habdalla, anni regni eius xxviimo. Luna quod arabice nu(n)cupatur al muharram.* So the date is: In the morning of Monday, the 28th of October (=11th of Muḥarram) of year 976 of the Hispanic era (938 of the Christian era), year 27th of ^cAbd al-Rahmān's kingdom. In the transcription by Clark [1920: 63], as cited by Diaz y Díaz [1995: 128, n. 393], apart from indicating developed abbreviations and standardized spelling of some words, namely *scripsi* and *perueni*, the indication *ora iiiia* is omitted and because of this *iii kalendas nouembres* (in nominative) is stated instead of the correct *iiii kalendas novuembries*; also he reads *Almuḥarran* instead of *al muharram*, as is actually written in the manuscript subscription. Dating by means of a *subscriptio* indicating the years of the Emperor's reign is a characteristic feature not only of Latin, but of Greek and Arabic manuscripts as well.

³⁰ Arabic glosses in Mozarabic manuscripts are not exceptional. See for instance, Millàs Vallicrosa [1932].

³¹ Diaz y Díaz [1995: 64-69].

³² Menéndez Pidal [1959: 190-191, fig. 3].

³³ “The oldest numerals and the oldest zero written in the West”.

³⁴ Labarta - Barceló [1988: 54-55]. P. Kunitzsch indicates me in a personal letter that we can also find pseudo-zero symbols in sexagesimal astronomical tables.

Menéndez Pidal these quantities are written “con unos extraños caracteres que en ocasiones tienen valor absoluto para las decenas y centenas justas y en otras componen su valor con relación a la posición”³⁵. Nevertheless, the figures are neither Hindu-Arabic nor positional. A. Labarta and C. Barceló, aware of the similarities and differences between these ciphers and *rūmī* figures, conclude that these figures are Coptic numerals, another variant of the Greek cursive alphabet used in Egypt³⁶. D. A. King considers the manuscript to be 13th century and states that this Arabic note shows “a curious numerical notation” which “represents an intermediary phase between the Arabic *abjad* and the positional Hindu-Arabic notations”³⁷. In fact, as can be inferred from Table I, these ciphers are related to –but not identical with– Greek alphanumerical notation and seem to represent an intermediary phase between Greek notation and *rūmī* figures, possibly through a Coptic version.

The Urgell manuscript is probably not the only ancient Mozarabic manuscript copied in the peninsula in Visigothic script with alphanumerical notation alongside Roman numeration, although, in the words of A. Millares Carlo³⁸, “el sistema numeral romano fue el único empleado en los códices y documentos de letra visigótica”³⁹. However, as far as I know, it is the only one that has survived, at least according to the catalogues; though, the information given in most catalogues does not mention any kind of numbering for chapters, quaternions and rubrics in general, either in Roman numerals or in any other kind of notation⁴⁰.

³⁵ “With some bizarre characters, which sometimes have absolute value for exact tens and hundreds and sometimes make up their value depending on their position”.

³⁶ Labarta - Barceló [1988: 54-55].

³⁷ King [2001: 314, fig. D. 4].

³⁸ Millares Carlo [1983: I, 281 & III, 450-453].

³⁹ “The Roman numeral system was the only one used in manuscripts and documents (written) in Visigothic script”.

⁴⁰ As reported by King [2001: 17] “Some catalogues devote but a line or two to each manuscript, so that, for example, pagination in an unusual notation would not be mentioned.” and “Catalogues detailed enough that, for example, even such unusual features as marginalia featuring ciphers are mentioned, are few indeed”.

G. Menéndez Pidal reports Greek and Hebrew alphanumerical notation⁴¹ in an appendix to an arithmetical treatise, taken from Isidore's *Etimologiae*, annexed by the scribe Vigila to the *Albeldensis* codex dated 976.

Probably the major differences between the Greek or Coptic notation and the *rūmī* ciphers used in al-Andalus and the Maghrib are due in the beginning to the unquestionable influence of Arabic *ductus* (which, incidentally, had probably affected Coptic figures before their possible introduction in al-Andalus), and later on to some mnemonic verses, used in the Maghrib, from at least the 16th century onwards. The verses are found in an anonymous manuscript on arithmetical notations entitled *Kitāb fi-hi rashm*⁴² *al-zimām* *alā al-tamām* copied in the 16th century⁴³ as well as in an opuscule by Alḥmad ibn al-Ḥājj al-^cAyyāshī Sukairij entitled *Irshād al-muta^callim wa-l-nāsī, fi ḥifat ashkāl al-qalam al-fāsī*, dated in the 19th century, a commentary on a treatise in verse (*urjūza*) attributed to the Maghribi polygraph ^cAbd al-Qādir al-Fāsī (d. 17th century)⁴⁴. The *urjūza* gives a popularized description of the *rūmī* figures, comparing the shape of each cipher to single or combined Arabic letters, which accounts for the distorted figures we find in the latest documents.

A similar system was used also referring to Hindu-Arabic figures and reported in al-Andalus by ^cAlī b. M. al-Qalaṣādī⁴⁵ (15th c.) and in the East by Ḥusayn ibn Muḥammad al-Mahallī al-Shāfi^cī⁴⁶ (18th c.), although the poems mentioned may, of course, be older.

⁴¹ Menéndez Pidal [1959: 192-193].

⁴² For the term *rashm* cf. the manuscript El Escorial, árabe 1933 δ, folio 1r, in Sánchez Pérez [1935: 98-99] and Dozy [1927: 531-532] s.v. *rashm*: "autre prononciation de *rasm*", and *rashm al-zimām*: "les chiffres employés dans l'enregistrement et qui sont formés de monogrammes ou abréviations des mots arabes qui servent à la numération".

⁴³ Sánchez Pérez [1935: 99-101].

⁴⁴ Cf. Colin [1933: 194-195], Sánchez Pérez [1935: 104] and Lamrabet [1994: 151-153, num. 536].

⁴⁵ Cf. Lamrabet [1994: 119-123, num. 454].

⁴⁶ Cf. Kunitzsch [2003].

According to M. Aballagh⁴⁷, *rūmī*, that is to say *lato sensu* Byzantine⁴⁸, is the oldest documented denomination mentioned by Maghribi mathematicians from the 12th century. Al-Ḥāṣṣar, Ibn al-Bannā, and Ibn al-‘Atīq, among others, all dedicated a chapter in their mathematical treatises to *rūmī* ciphers, which seem to have been used by the Sultan’s chancellery, and to the corresponding systems of addition, subtraction, multiplication and division, explained by means of the *ghubārī* positional ciphers which they used for their mathematical calculations. Later on, the name *al-rashm al-zimāmī* was used to refer to these figures. The term is post-12th century, and comes, probably, from the word *zimām* meaning “register”. The latest attested denomination is *al-qalam al-fāsī*, because the ciphers were used in Fās, according to the author of the article, which is also the interpretation proposed by G. S. Colin⁴⁹. Both *al-rashm al-zimāmī* and *al-qalam al-fāsī* were used in commercial transactions and notarial documents such as the ones we find in al-Andalus.

II. 2. Derivates of Greek alphanumerical notation related to the figures used in the Urgell manuscript Table I)

Having established that the notation appearing in the Urgell manuscript alongside to Roman numbers is not Arabic, the origin of this alphanumerical notation remains to be determined.

Table I shows some samples of the alphanumerical figures appearing in the Urgell manuscript (see also Table II and Fig. 1), dated 938, and in El Escorial R.II.18 (Fig. 2), dated probably in the 9th century, which are very similar.

In this table, I also show the following: an example of Greek canonical minuscule cursive script; some samples of Coptic figures, taken from Egyptian papyruses dated in the 9th and 11th centuries; some examples of *rūmī* figures in al-Andalus, taken from the table published by González Palencia covering documents from Toledo dated in the late 12th and early 13th centuries, and from Labarta-Barceló’s tables, corresponding to

⁴⁷ Cf. Aballagh [2002].

⁴⁸ *Encyclopédie de l’Islam*, vol. VIII s.v. Rūm.

⁴⁹ Colin [1933:195]. Cf. however n. 3.

Valencian Mudejar and Morisco documents, dated from the 14th to the 16th centuries and the ciphers taken from an Arabic manuscript dated in the mid-16th century, reported by Sánchez Pérez⁵⁰.

I. 2. I. Comparison between Greek and Coptic⁵¹ figures in Table I

First of all, it is interesting to stress the differences between the minuscule alphanumerical notation in the 9th century Greek and Coptic manuscripts. Looking at Table II, we find that only four ciphers are markedly dissimilar, namely those representing 4, 6, 10 and 90.

Number 4, corresponding to the Greek δ (*delta*), appears in Coptic manuscript so stylized that the round stroke of *delta* almost disappears, resulting in a sign similar to *lambda*.

In the minuscule Greek alphanumerical notation we find three forms (Τ, Κ, Ζ)⁵² to denote the number 6, while, in the Coptic tradition we find a form ς̄ (*coor*), which is not a letter but a sign used only for numerals.

Number 10, coming from the Greek *iota*, is in general denoted by a sign similar to *gamma* in Coptic manuscripts.

Finally, we find in Greek manuscripts the symbols: υ and λ⁵³ to denote the number 90, while in Coptic documents, this number is written in a form very similar to the one used for the number 6.

⁵⁰ Unfortunately, some excellent surveys mentioning this alphanumerical notation, for instance, Dietrich [1952: 259-270], do not include images (either photographs or sketches) of these signs, and therefore we cannot include them in our comparative table. We hope to obtain microfilm copies of the manuscripts surveyed and complete this table in the near future. We will then be in a position to make a comprehensive survey of the development of this alphanumerical system.

⁵¹ No doubt the shape of some Coptic numerals evolved from Greek symbols, through Egyptian artistic channels, and particularly under the influence of Arabic script, independent of the natural evolution of Greek characters. At any rate, the script used in Greek manuscripts, especially dealing with liturgical and religious texts, acquired and copied in Egypt by Copts, continued to exert a non-dismissible influence.

⁵² Cf. point I.1. "Greek alphanumerical notation and its derivates".

⁵³ Cf. point I.1. "Greek alphanumerical notation and its derivates".

II. 2. 2. Comparison of the above mentioned ciphers with the figures appearing in the Urgell manuscript⁵⁴ (Table I)

Having established the differences between the Greek⁵⁵ and the Coptic minuscule alphanumerical notations in Table I, we can now compare these ciphers to the figures appearing next to the Roman numbers in the Urgell manuscript.

Taking into consideration only the divergent forms appearing in the table, we find the following results:

Number 4 follows the Coptic tradition, not only in the Urgell and El Escorial manuscripts, but also in the rest of manuscripts containing *rūmī* ciphers shown in Table I.

Number 5 in the Urgell manuscript seems to be a Greek *epsilon* or Coptic *τον*, written in two strokes, the 2nd stroke being drawn in the opposite direction.

The sign representing the number 6 in the Urgell and El Escorial manuscripts seems to come directly from the Greek stigma (Ϛ) and differs from the special symbol $\overline{\epsilon}$ (*coor*), used in the Coptic notation, as mentioned above.

Number 10 follows the Greek symbol for *iota*, and not the *gamma* shape we generally find in the Coptic manuscripts.

Number 30 is similar, but not identical, to both Greek and Coptic minuscule cursive form, while number 50 is also very similar to both

⁵⁴ As mentioned above, the figures appearing in the manuscripts Urgell, MDU 604, and El Escorial R.II.18, do not present outstanding differences. Therefore, what is said of Urgell manuscript referring to ciphers applies, in general, also to El Escorial.

⁵⁵ According to Devreesse [1954: 32], the oldest dated Greek manuscript in minuscule (Leningrad, Publ. Bibl. 219) contains the text of the Gospels and was copied in Theodoros Studites monastery in 835, while the oldest preserved manuscripts copied in the Italian scriptoria in Greek minuscule are dated in the early 10th century, as, for instance, the manuscript Mosq. Bibl. Univ. 1, containing the writings of Basil and Gregory of Nyssa, dated *circa* 911, reported by Devreesse [1954: 289]. On the other hand, Groningen [1963: 34] indicates that the cursive assumed the definite forms of the minuscule in the 9th century and Ullman [1969: 52-53] considers the possible influence of the Caroline minuscules of the Roman alphabet.

Greek and Coptic forms, but written in uncial alphabet⁵⁶ instead of cursive minuscule.

Number 90 on the other hand, comes clearly from the Coptic form and is completely different from any of the two symbols: ϙ and Ϛ, which we find in Greek manuscripts to denote the number 90, as mentioned above.

This form for 90, similar to the shape appearing in the documentation featuring *rūmī* figures⁵⁷, seems to be the source of both the Andalusī and Maghribī traditions, although sometimes written from right to left.

As regards the morphology of the alphanumeric notation, the scribe of the Urgell manuscript does not seem to realize the Greek origin of the numbers but uses stereotyped forms, which were to become increasingly distorted over the following centuries.

II. 2. 3. Rūmī ciphers

This comparison ends in the 10th century, since the figures attested later are added to the table only to illustrate the subsequent development of Greek, or perhaps Coptic, alphanumeric notation in the Arabic milieu. The comparison of these ciphers may suggest a parallel development of *rūmī* figures in al-Andalus⁵⁸ and in the Maghrib, with a possible late convergence of the two traditions in Fās. This is, in my opinion, a very interesting topic which I plan to research in more detail in a future survey.

⁵⁶ According to Thompson [1940: 116], Greek uncial survives in liturgical books, and its derivate, the half-uncial, in manuscripts written in minuscule during 9th-10th centuries for scholia, rubrics, titles and “certi altri scopi speciali”, although only the letter standing for 50 seems to be written in uncial in the Urgell manuscript. See Thompson [1940: 119] for samples of Greek alphanumeric notation in uncial.

⁵⁷ See table I.

⁵⁸ As indicated above, *rūmī* ciphers are attested in al-Andalus in notarial documents, from the end of the 12th century, and were used in the Maghrib for administrative, commercial and notarial purposes, as early as the 12th century. On the other hand, the figures documented in religious and technical manuscripts – Urgell, MDU-604 and El Escorial R.II.18 – approximately from the 9th to the 10th century seem to link the Greek and *rūmī* alphanumeric notation, probably through the Coptic version.

G. S. Colin⁵⁹ compares Greek with Coptic, as well as with *rūmī* alphanumerical notation. However, he takes as a basis for his comparative survey the “minuscule Greek printing alphabet” instead of the actual handwritten minuscule Greek alphabet used in manuscripts from the 9th century AD onwards.

For *rūmī* ciphers, Colin⁶⁰ suggests the following development: Greek alphanumerical notation - Coptic numerical notation in Egypt (or Syria) - Muslim Spain - Maghrib, which in general appears to be, acceptable. However, he seems unaware of the possibility that I mentioned above of a parallel development, and he states that in non-Islamic periods no Greek alphanumerical notation is recorded in the Italian Peninsula⁶¹, whereas in fact most of the preserved Greek manuscripts which were copied in *scriptoria* of Greek-Latin tradition in the Italian Peninsula, and even in Rome⁶², needless to say, show Greek alphanumerical notation.

II. 3. The illuminated initials in the Urgell manuscript and in other related codices

Besides the evidence provided by the alphanumerical notation, other features furnish additional information on the original from which the Urgell manuscript was copied. Although the notation seems to be mostly Coptic, the illuminated initials point to a Greek tradition.

⁵⁹ Colin [1933 : 193-215].

⁶⁰ Colin [1933: 213].

⁶¹ Colin [1933: 196]: “Or, pour les périodes non-islamiques, on ne possède, ni pour l’Espagne, ni pour l’Italie, le moindre indice de l’emploi dans ces pays d’une série de vingt-sept chiffres à valeur absolue”.

⁶² Such as Ms. Vatican Greek 2029 (10th c.) and 2053 (11th c.), probably written in Southern Italy, Devreesse [1954: pl. XVa & XVb], as well as Ms. Vatican Greek 1666, containing a Greek version of Gregory the Great’s *Dialogi*, which is, according to Devreesse [1954: 26], the first testimony of “la seconde période de l’onciale” which leads to the half uncial, written in 800, probably in Rome. Cf. also Ullman [1969: 51, pl. IVc]. There was a quite important Greek colony in Rome and a number of popes were of Greek origin. Zacharias (middle of 8th century) translated to Greek Gregory the Great’s *Dialogi*. See at this respect Bischoff [1985: 209].

The characteristics of the illuminated initials of the Urgell manuscript MDU-604 recall the Mozarabic style, especially certain features such as the use of illumination without any symbolic value, as can be seen in Fig.1, instead of the more common illustration related to the text, or the somewhat naïf but lively and vigorous ornamentation, with intense, bright colours (ochre, red, blue and green) forming zoomorphic and anthropomorphic letters⁶³. Among the motifs used, there are combinations of pairs of fishes, birds and snakes or worms biting their tails, as well as a man's head, torso or complete body, always viewed in profile⁶⁴.

The same style of illumination appears in two manuscripts from Toledo⁶⁵: Mozarabic breviary (Madrid, B. N. 10001), dated 9th-10th century, and *Vitae Patrum*, (Madrid, B. N. 10007), written in 902. In both manuscripts we find elaborate zoomorphic initials, more sophisticated than the Urgell manuscript illumination but less so than the miniatures from the San Millán de la Cogolla scriptorium⁶⁶, dated 10th to 11th century, in which the style is similar, above all in the anthropomorphic letters⁶⁷.

This notwithstanding, parallels are also found in manuscripts from the southern Italian Peninsula, for instance, in the above mentioned Greek manuscripts Vatican 2029, and 2053, both using Greek alphanumerical notation for entries⁶⁸, as well as from Rome, as in Ms. Vatican 1666⁶⁹. In contrast, Coptic manuscripts of the period present geometrical designs and floral bands and do not, in general, combine fabulous contorted animals forming ornamental letters.

⁶³ Ibarburu [1994: 140 & 274-275].

⁶⁴ Composite initials of this kind are also found in Celtic and Germanic ornamentation.

⁶⁵ Dominguez Bordona [1933: 288-290, num. 671 & 674, fig. 251 & 252].

⁶⁶ Menéndez Pidal [1958: 7-19 and illustrations].

⁶⁷ Cf. for miniatures Dominguez Bordona [1958: fig. 10 & 13].

⁶⁸ Cf. Devreesse [1954: pl. XVa & b].

⁶⁹ Where for the first time we find (in Greek manuscripts) an adorned initial, as reported by B. A. van Groningen [1963: 33, n. 1]. Commentary and photography of the only four illuminated initials in Grabar (1972), pp. 30-31, fig. 64-66, consists essentially in letters formed by fishes, similar to the Urgell ms. decoration. Cf. also Ullman [1969: pl. IVc].

There is another feature of the Urgell manuscript MDU-604 which is shared by some Mozarabic Latin manuscripts, such as the ones written in Toledo⁷⁰, and by many of the Greek, and Latin, manuscripts written from the 8th to the 11th centuries in southern and (less frequently) northern⁷¹ Italy and Rome. I am referring to the illuminated initials. They seem to have been drawn by the scribe before the completion of the handwritten text. The text, then, adjusts itself to the shape of the illustrations, as can be seen in Fig. 1. This is confirmed by the fact that the style of the illuminated initials of the Urgell manuscript, technically very simple and unsophisticated, seems to be the work of a calligrapher rather than of a miniaturist⁷².

III. Conclusion

Once we have definitively excluded the assumption that the ciphers in the manuscript Urgell MDU-604 were Hindu-Arabic, the evidence here submitted proves, in my opinion, that the notation in this manuscript represents an intermediate stage between Greek and *rūmī* non-positional alphanumerical notation, possibly through a Coptic version.

The Greek alphanumerical notation might have been known in the south of the Iberian Peninsula from at least the 6th century onwards. The Byzantines occupied the southeast of the peninsula from the middle of the 6th to the early 7th century, and we know, for instance, that the Greek colony of Merida lasted until the end of the 7th century⁷³.

This notwithstanding, the Mozarabic scribe could have been subject to a mixture of other influences. On the one hand, he may have known the Coptic alphanumerical notation, perhaps introduced into al-Andalus in

⁷⁰ Cf., for instance, plates V, VIII, XV in Mundó [1965] and figs. 251, 252 in Domínguez Bordona [1933], which does not seem the case of manuscripts written in the scriptorium of San Millán de la Cogolla, as per the miniatures reproduced in Menéndez Pidal [1958].

⁷¹ Isidore's *Etymologiae*, 8th-9th century, in Ehrle - Liebaert [1912: 10].

⁷² This is not unusual. Cf. in this respect Lemaire [1989: 62, n. 39] and Devreesse [1954: 55].

⁷³ Cf. Ruiz [1988: 197-198, n. 25].

religious writings by monks coming from North Africa, either in the last third of the 6th century⁷⁴ or at the time of the Arab invasion⁷⁵. He may as well have been familiar with the Greek alphanumerical notation possibly introduced into al-Andalus after the conquest of the territory by the Arabs, who, as we said above, were using it in Egypt. An intermediate evidence could be the above-mentioned El Escorial R.II.18 manuscript.

On the other hand, we cannot rule out the possibility that the scribe was merely reproducing the Greek alphanumerical notation reflected in the exemplar from which the manuscript was copied.

So there are three main possibilities:

1. The scribe may have been familiar with the Greek notation, which could have been used in the Byzantine milieux on the southeast of the Iberian Peninsula. I have in mind the brothers from Byzantine origin, Isidore and Leander of Seville. In fact, Leander met Gregory the Great during his stay in Constantinople and the future Pope dedicated one of his works to him. So, Byzantine tradition may have lasted in religious milieux and we cannot rule out the possibility that this was the origin of the alphanumerical notation in Urgell manuscript.
2. The notation in the Urgell manuscript may reflect the Greek – or perhaps Coptic – alphanumerical notation that may have been introduced in al-Andalus from the Eastern Mediterranean. These ciphers could have been used, at the moment of the copy, in limited circles, religious or not. There is supporting evidence for their use in non-religious milieux in the figures that appear in a marginal note in Arabic, in a short treatise on land-surveying (El Escorial R.II.18), as mentioned above, and in the *rūmī* figures attested in al-Andalus some centuries later, similar – but by no means identical – to those of Urgell and El Escorial manuscripts (Table 1).

⁷⁴ Cf. Ruiz [1988: 198, n. 26].

⁷⁵ For direct contacts between Spain and the Near East, cf. Lowe [1972B: 77-78 & 1972c: 546- 574].

3. The exemplar, copied in al-Andalus⁷⁶, may come ultimately from a Greek-Latin scriptorium, where Latin and Greek traditions survived, rather than from an exclusively Latin writing centre. The Greek-Latin scriptoria would follow the tradition of Greek religious manuscripts, either in Rome, where we know of several Greek monasteries before the 10th century⁷⁷, or in the south of the Italian Peninsula, where contact with Greek culture was probably never lost, not to mention the Byzantine influence⁷⁸; or perhaps in Sicily, conquered by Arabs at the end of 9th century, where Gregory the Great had founded six monasteries and where, we can assume, his writings would have been profusely copied. A Roman or southern Italian origin would explain the combination of western and eastern elements in the ornamentation and numbering of quires and rubrics in general⁷⁹.

Thus, in spite of the difficulty of determining how and when these ciphers reached al-Andalus, although the shape of some figures suggests a Coptic influence, it is clear that they can no longer be considered as the oldest occurrence of Hindu-Arabic numerals in the Iberian Peninsula; rather they seem to be the oldest evidence in the peninsula of an ultimately Greek alphanumerical notation system, which was as important in the Near East and Eastern Mediterranean as Roman numerals were in Western Europe, before definitively adopting Hindu-Arabic positional ciphers.

⁷⁶ Probably in Cordova, according to Diaz y Diaz [1995: 129], although Mundó [1994: 140 & 1998: 514, n. 66] considers that it was copied in Toledo.

⁷⁷ Cf. Ullman [1969: 51] and Bischoff [1985: 209].

⁷⁸ According to Devreesse [1954: 57-58], a great quantity of Greek manuscripts, especially dealing with religious literature, were copied in the southern part of the Italian peninsula "une bande de terrain qui suit les côtes de l'Italie depuis les monts Albains, La Campanie, la Calabre, les rives orientales de la Sicile et remonte sans interruption jusqu'aux Pouilles". Battelli [1949: 218], when dealing with Roman numbers, states: "Fino al sec. XIII fu usata universalmente nei manoscritti latini la numerazione secondo l'uso romano; solo nell'Italia Meridionale si seguì talvolta l'uso greco".

⁷⁹ In order to establish the origins and transmission of this text, a codicological and palaeographical survey as well as textual criticism of the manuscript is being prepared and will be published in the near future.

Table I⁸⁰

N.	Greek 9 th c. ⁸⁷	Coptic Egypt, 9 th c. ⁸⁸	R.II.18 Al-Andalus, 9th c.? ⁸⁹	MDU-604 Al-Andalus, 10th c.	Coptic Egypt? 11 th C. ⁹⁰	Toledo 12 th -13 th C. ⁹¹	Valencia 14 th -16 th C. ⁹²	Rūmī figures Maghrib 16 th c. ⁹³
1	Ճ	Ճ	Ճ	Ճ	Ճ	Ճ	Ճ	Ճ
2	Յ	Յ	Յ	Յ	Յ	Յ	Յ	Յ
3	Ր	Ր	Ր	Ր	Ր	Ր	Ր	Ր
4	Ջ	Ջ	Ջ	Ջ	Ջ	Ջ	Ջ	Ջ
5	Ւ	Ւ	Ւ	Ւ	Ւ	Ւ	Ւ	Ւ
6	ՌԸ	ՌԸ	ՌԸ	ՌԸ	ՌԸ	ՌԸ	ՌԸ	ՌԸ
7	Յ	Յ	Յ	Յ	Յ	Յ	Յ	Յ
8	Վ	Վ	Վ	Վ	Վ	Վ	Վ	Վ
9	Փ	Փ	Փ	Փ	Փ	Փ	Փ	Փ
10	Լ	Լ	Լ	Լ	Լ	Լ	Լ	Լ
20	Ա	Ա	Ա	Ա	Ա	Ա	Ա	Ա
30	Խ	Խ	Խ	Խ	Խ	Խ	Խ	Խ

40	٤	٤		٤	٤	٤٤	٤٤	٤٤
50	٥	٥		٥	٥	٨٩٦	٨٩٦	٨
60	٦	٦		٦	٦	٣٣٦	٦	٦
70	٧	٧		٧	٧	٠	٠	٠
80	٨	٨		٨	٨	٥٦٦	٥٦٦	٨
90	٩	٩		٩	٩	٤٤٤	٤٤٤	٩
100	P ⁸⁸	١٠	٨	٨		٢٢٢	٢٢٢	٢

⁸⁰ Examples of Greek and Greek derived alphanumerical notations from the 9th to the 16th centuries.

⁸¹ J. A. Sánchez Pérez [1935: 104].

⁸² Labarta - Barceló [1988: 22-24, table V]. The example of Valencia, from the early 13th century, serves as a bridge between the *rūmī* figures of the late 12th-early 13th century in Toledo and those of the 16th century in Morocco.

⁸³ Levi della Vida [1933: 281-283] and Labarta - Barceló [1988: 20, table III]. Cf. González Palencia [1926-1930: vol. I, 48].

⁸⁴ Bartina [1968: 99-110].

⁸⁵ Labarta - Barceló [1988: 54-55] and King [2001: 314, fig. D-4]. Cf. Menéndez Pidal [1959: 179-208, fig. 3].

⁸⁶ Hasitzka [1990: 285-287, pl. 131].

⁸⁷ Van Groningen [1963: 34, fig. 5], minuscule cursive script found in Greek manuscripts dated in the 8th and the 9th century.

⁸⁸ Cf. note 4.

⁸⁹ Cf. note 5.

Table II

1	$\sqrt{1}$ १	20	$\sqrt{20}$ २०
2	$\sqrt{11}$ ११	30	$\sqrt{30}$ ३०
3	$\sqrt{21}$ २१	40	$\sqrt{40}$ ४०
4	$\sqrt{31}$ ३१	50	$\sqrt{50}$ ५०
5	$\sqrt{41}$ ४१	60	$\sqrt{60}$ ६०
6	$\sqrt{51}$ ५१	70	$\sqrt{70}$ ७०
7	$\sqrt{61}$ ६१	80	$\sqrt{80}$ ८०
8	$\sqrt{71}$ ७१	90	$\sqrt{90}$ ९०
9	$\sqrt{81}$ ८१	100	$\sqrt{100}$ १००
10	$\sqrt{91}$ ९१		

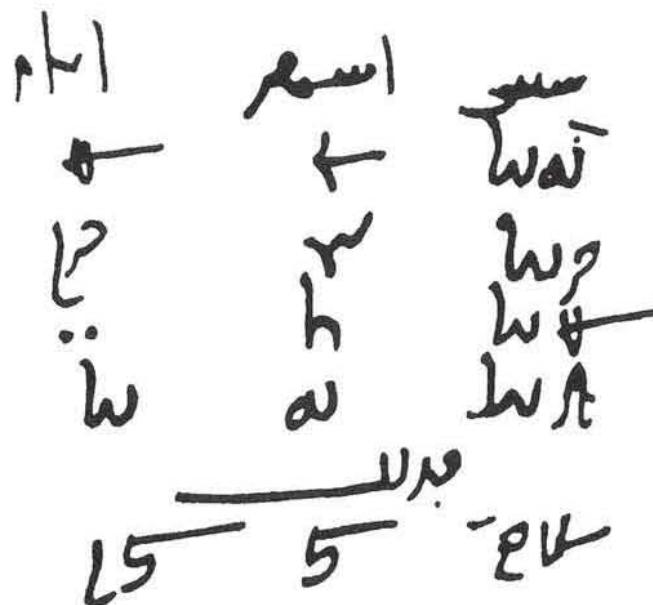
Fig. 1

de derradum fructu.
Illiuidum fruct
qui solitua si furo
ri dicati accedit
hucundus fructu. ea
adprendit hamum
etur. eas sculu corde
sum diebit. Cyprius
agomamibus trax.
fr. qui uppares
attinere metatur
In regno celorum. Illam
compencauit etiam
cristianis etiam
enam. Salpi. et
in uermonem de
huc uerbi turquis
uid. 
Generariorum neque
petitur. In regnum
secundum pudentia
rectitudinibus et
nibus nihil nisi
misericordia
et dilectione. duo illi per
upere. quod dulique
in illius amorem
nihil cogantur nonque
unumquam induentur

" a v

Folio 63v of the Urgell manuscript MDU-604 showing the numbers 15 and 16, indicating the *capitula*, and the number 2, noting the *quaternio*, in both Roman numerals and Greek derived alphanumerical notation, as well as a sample of illumination and text indentation.

Fig. 2



Folio 55r of the El Escorial manuscript, R.II.18, which shows an alphanumerical notation very similar to the one in the Urgell manuscript (see Table I).

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V. Bibliography

- ABALLAGH M. [2002],
 Aballagh M., "Iktishāf kitāb riyādī jadīd li-Ibn al-Bannā'", *Da'wat al-Haqq*, 363, January, 2002, pp. 126-132.
- ALTURO I PERUCHO, J. [2003],
 Alturo i Perucho, J., *Història del llibre manuscrit a Catalunya*, Barcelona, 2003.
- BARAUT, C. [1992]
 Baraut, C., "Testament del bisbe Sisebut", *Catalunya Romànica*, vol. VI (Alt Urgell, Andorra), Enciclopèdia Catalana, Barcelona, 1992, p. 54.
- BARTINA, S. [1968]
 Bartina, S. (1968), "Cifras coptas y cultura árabe", *Studia Papyrologica* 7, 1968, pp. 99-110.
- BATTELLI, G. [1949]
 Battelli, G., *Lezioni di Paleografia*, Città del Vaticano, 1949.
- BISCHOFF, B. [1985]
 Bischoff, B., *Paléographie de l'Antiquité Romaine et du Moyen Âge Occidental*, Paris, 1985.
- BURNAM, R. [1912-1925]
 Burnam, R., *Palaeographia Iberica. Fac-similés de manuscrits espagnols et portugais du IXe au XVIe siècle*, París, 1912-1925.
- CLARK, Ch. U. ([1920]
 Clark, Ch. U., *Collectanea Hispanica*, Paris, 1920.
- COLIN, G. S. [1933]
 Colin, G. S., "De l'origine grecque des «chiffres de Fès» et de nos «chiffres arabes», *Journal Asiatique* 222, 1933, pp. 193-215.
- DEVREESSE, R. [1954]
 Devreesse, R., *Introduction à l'étude des manuscrits grecs*, Paris, 1954.
- DÍAZ Y DÍAZ, M. C. [1995]
 Diaz y Diaz, M. C., *Manuscritos visigóticos del sur de la Península*, Sevilla, 1995.
- DIETRICH, A. [1952]
 Dietrich, A., "Zwei arabisch beschriftete Knochenstücke aus dem mittelalterlichen Ägypten", *Le Museon: Revue d'Études Orientales* 65, 1952, pp. 259-270.
- DOMINGUEZ BORDONA, J. [1933]
 Dominguez Bordona, J., *Manuscritos con pinturas*, Madrid, 1933.

- DOMÍNGUEZ BORDONA, J. [1958]
 Dominguez Bordona, J., *Ars Hispaniae*, vol. XVIII, Madrid, 1958.
- DOZY, R. [1927]
 Dozy, R., *Supplément aux Dictionnaires arabes*, vol. I, 2^a ed., Leyden - Paris, 1927.
- EHRLE, F. - LIEBAERT, P. [1912]
 Ehrle, F. - Liebaert, P., *Specimina Codicum Latinorum Vaticanorum*, Roma, 1912.
- GARDTHAUSEN, V. [1913]
 Gardthausend, V., *Griechische Palaeographie. Die Schrift, Unterschriften und Chronologie im Altertum und im byzantinischen Mittelalter*, vol. 2, Leipzig, 1913.
- GONZÁLEZ PALENCIA, A. [1926-1930]
 González Palencia, A., *Los Mozárabes de Toledo en los siglos XII y XIII*, (4 vols.), Madrid, 1926-1930.
- GRABAR, A. [1972]
 Grabar, A., *Les manuscrits grecs enluminés de provenance italienne (IX^e - XI^e siècles)*, Paris, 1972.
- GRONINGEN, B.A. VAN [1963]
 Groningen, B.A. van, *Short Manual of Greek Palaeography*, Leyden, 1963.
- GUERGOUR, Y. [2000]
 Guergour, Y., "Les différents systèmes de numérotation au Maghreb à l'époque ottomane: l'exemple des chiffres *rūmī*", *Science, Technology and Industry in the Ottoman World* (ed. E. İhsanoğlu, A. Djebbar and F. Günergun), *Proceedings of the XXth International Congress of History of Science* (Liège, 20-26 July 1997), vol. VI, (Turnhout. Belgium) Brepols, 2000, pp. 67-74.
- HASITZKA, M. R. M. [1990]
 Hasitzka, M. R. M., (unter Mitarbeit von H. Harrauer), *Neue Texte und Dokumentation zum Koptisch-Unterricht*, Wien, 1990.
- IBARBURU, M. E. [1994]
 Ibarburu, M. E., *Catalunya Romànica*, vol. XXIII, Encyclopædia Catalana, Barcelona, 1994, pp. 140 & 274-275.
- KING, D. A. [2001]
 King, D.A., *The Ciphers of the Monks, A Forgotten Number-Notation of the Middle Ages*, Stuttgart, 2001.
- KUNITZSCH, P. [2003]
 Kunitzsch, P., "The transmission of Hindu-Arabic Numerals reconsidered", *The Enterprise of Science in Islam. New Perspectives*.

- Ed. By J. P Hogendijk and A. I. Sabra. Cambridge, MA – London, 2003, 3-21.
- LABARTA, A., - BARCELÓ, C. [1988]
Labarta, A., - Barceló, C., *Números y cifras en los documentos arábigohispanos*, Córdoba, 1988.
- LAMRABET, D. [1994]
Lamrabet, D., *Introduction à l'histoire des mathématiques maghrébines*, Rabat, 1994.
- LEHMANN, P. [1936]
Lehmann, P., "Blätter, Seiten, Spalten, Zeilen", *Zentralblatt für Bibliothekswesen* 53, 1936, pp. 333-361 and 411-442, reprinted in *idem, Erforschung des Mittelalters*, III, 1960, pp. 1-59.
- LEMMAIRE, J. [1989]
Lemmaire, J., *Introduction à la codicologie*, Louvain-La-Neuve, 1989.
- LEVI DELLA VIDA, G. [1933]
Levi Della Vida, G., "Appunti e quesiti di storia letteraria araba; Numerali greci in documenti arabo-spagnoli", *Rivista degli studi orientali* 14 (1933), pp. 249-283.
- LOWE, E. A. [1972a]
Lowe, E. A., "Studia palaeografica. A contribution to the History of Early Latin Minuscule and to Dating of Visigothic Manuscripts", *Sitzungsberichte der Königlich Bayerischen Akademie des Wissenschaften*, Philosophisch-philologische und historisch Klasse, Jahrgang 1910, 12. Abhandlung. Munich, 1910, reprinted in *Palaeographical papers*, 1907-1965, vol. I, Oxford 1972, pp. 2-65.
- LOWE, E.A. [1972b]
Lowe, E. A., *The Beneventan Script: A History of the South Italian Minuscule*, 2 vol. Roma, 1980, reprinted in part as "The Beneventan Script: A History of the South Italian Minuscule. Preface and Introduction" in *Palaeographical papers* 1907-1965, vol. I, Oxford 1972, pp. 70-91.
- LOWE, E. A. [1972c]
Lowe, E. A., "Some facts about our oldest Latin Manuscripts", *The Classical Quarterly* XIX, 1925, pp. 197-208, reprinted in *Palaeographical papers*, 1907-1965, vol. I, Oxford 1972, pp. 187-202.
- LOWE, E.A. [1972d]
Lowe, E. A., "The «Script of Luxeuil»: A Title Vindicated", *Revue Bénédictine* LXIII, 1953, pp. 132-142, reprinted in *Palaeographical papers* 1907-1965, vol. II, Oxford 1972, pp. 389-398.

LOWE, E.A. [1972e]

Lowe, E. A, "Two Other Unknown Latin Liturgical Fragments on Mount Sinai ", *Scriptorium* 19, 1965, pp. 3-29, reprint in *Palaeographical papers* 1907-1965, vol. II, Oxford 1972, 546- 574.

MARTIN, H.-J. - VEZIN, J. (ed.) [1990]

Martin, H - J - Vezin, J. (ed.), *Mise en page et mise en texte du livre manuscrit*, Mayenne, 1990.

MENÉNDEZ PIDAL, G. [1958]

Menéndez Pidal, G., "Sobre el escritorio emilianense en los siglos X a XI", *Boletín de la Real Academia de la Historia*, 143, 1958, pp. 7-19.

MENÉNDEZ PIDAL, G. [1959]

Menéndez Pidal, G., "Los llamados numerales árabes en Occidente", *Boletín de la Real Academia de la Historia* 145, 1959, pp. 179-208.

MILLARES CARLO, A. [1983]

Millares Carlo, A., *Tratado de paleografía española*, (vol. I., texto, vol. II y III, Láminas), Madrid 1983.

MILLÀS VALLICROSA, J. [1932]

Millàs Vallicrosa, J., "El manuscrit mossaràbic n.º 49 del fons de Ripoll", *Butlleti de la Biblioteca de Catalunya* 7, pp. 337-339.

MUNDÓ, A. M. [1965]

Mundó, A. M., "La datación de los códices litúrgicos visigóticos toledanos", *Hispania Sacra* 18, 1965, pp. 1-25.

MUNDÓ, A. M. [1994]

Mundó, A. M., "La cultura artística escrita", *Catalunya Romànica*, vol. I, Encyclopèdia Catalana, Barcelona, 1994, pp. 133-162.

MUNDÓ, A. M. [1998]

Mundó, A. M., *Obres Completes I. Catalunya 1. De la romanitat a la sobirania*, Curial Edicions Catalanes, Abadia de Montserrat, 1998.

NEUGEBAUER, O. [1969]

Neugebauer, O., *The Exact Sciences in Antiquity*, New York, 1969.

PUJOL I TUBAU, P. [1917]

Pujol i Tubau, P., "De paleografia visigòtica a Catalunya: El Còdex de l'Apocalipsi, de Beatus, de la catedral d'Urgell", *Butlleti de la Biblioteca de Catalunya* 4, pp. 6 - 27.

RUIZ, E. [1988]

Ruiz, E., *Manual de codicología*, Madrid, 1988.

SANCHEZ PEREZ, J. A. [1935]

Sánchez Pérez, J. A., "Sobre las cifras rūmīes", *Al-Andalus, Revista de las escuelas de estudios árabes de Madrid y Granada*, vol. 3, Madrid-Granada, 1935, pp. 97-125.

STIENON, J. [1991]

Stienon, J., *Paléographie du Moyen Âge*, Paris, 1991.

TANNERY, P. [1920]

Tannery, P., "Les chiffres arabes dans les manuscrits grecs", *Mémoires scientifiques*, vol. IV, *Sciences exactes chez les Byzantins*, Paris 1920, pp 199-205.

THOMPSON, E. M. [1940]

Thompson, E. M., *Paleografia greca e latina*, Milano, 1940.

ULLMAN, B. L. [1969]

Ullman, B. L., *Ancient Writing and Its Influence*, Cambridge 1969.

WOEPCKE, F. [1986]

Woepcke, F., "Mémoire sur la propagation des chiffres indiens", *Journal Asiatique* 6^e serie, 1, 1863, reprinted in *Études sur les mathématiques arabo-islamiques, Nachdruck von Schriften aus den Jahren 1842-1874*, (ed. F. Sezgin), I-II, Frankfurt am Main, 1986, vol II, pp. 264-461.