

## ⋈ $\LaTeX$ : A package for typesetting “Byzantine” music

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### Abstract

Using Donald Knuth’s METAFONT, almost all the symbols of “Byzantine” music have been designed and organized in three font series: byzf, byyf and bzal. Musical phrases from the Hellenic ecclesiastical and folk music traditions are typeset using the ad hoc package `byzlatex` as examples.

### 1 Introduction

“Byzantine” music is the official music used by the Greek Orthodox Church for her liturgical needs; all other Christian Orthodox churches make use of the Western or European scales and notation. At the same time, “Byzantine” is the music used in folk music tradition in different areas throughout Cyprus and Greece. Efforts by admirers of the Western tradition at the beginning of the previous century seemed to succeed but eventually encountered the strong opposition of the people. In our time there has been a revival of the pure tradition, from the music and dances to the architecture and food recipes. Hundreds of schools specializing in the teaching of folk music (dancing, singing, chanting or playing instruments) have been founded by the Church, local city authorities, and private conservatories.

“Byzantine” music, along with its scales, notes and the rest of its symbols, is very little known in the West. This is understandable and expected since it belongs only to the tradition of a small nation among the thousands of local traditions. Be that as it may, some efforts have been made to design fonts containing the special symbols used in the musical phrases. Dr. Velissarios G. Gezerlis, Ph.D., has designed a program called *ByzWriter 2.0* [2] with which one is able to typeset “Byzantine” musical phrases in the Windows environment. Yet, no package has appeared in the (L<sup>A</sup>) $\TeX$  community to allow a Byzantine musician/ $\TeX$ nician to typeset his own phrases using his favorite editor and L<sup>A</sup> $\TeX$ ! Through the work presented in this paper, we hope to begin to remedy the lack of “Byzantine” music fonts and L<sup>A</sup> $\TeX$  styles.

The authors of this paper belong to the student-teacher category, with the first being the student and the second the teacher. We both belong to that group of people who are in the middle of this comeback of tradition, Panagiotis being Lampadarios (official title for a cantor in the Orthodox Church) at St. George’s church in Rion, Patras, while Ioannis is

a member of “The Aegean Akritae”, a folk dancing group, and is also studying “Byzantine” music.

At the beginning of my (Ioannis’) studies, I hoped to have all the tones and marks used by “Byzantine” Music, typeset and printed in banner size. I thought that this would be a nice way to look at them and eventually learn them by heart. I set out looking among the CTAN archives for “Byzantine” letters and music tones but they were nowhere to be found. My initial disappointment turned into hope when I bought Donald Knuth’s famous book [5] on how to design fonts. Since that day I have not stopped designing and redesigning the characters of the three fonts presented in this paper. I can testify that Donald Knuth’s warning<sup>1</sup> comes true!

### 2 A short history of “Byzantine” music

In April, 311 AD, the Emperor of the Western part of the Roman Empire, Constantine the Great, issued an edict that put an end to the Great Persecution of the Christians. Two years later, on June 13, he and the Emperor of the Eastern Roman Empire, Licinius, promulgated at Mediolanum (today’s Milan, Italy) an edict that allowed all citizens of the Empire to worship whatever Deity they wanted. That day marked the birth of Christianity as an accepted religion. Ten years later Christianity became the official religion of the Roman Empire. On May 11, AD 330, Constantine, as the only ruler of the state, selected Byzantium, a small town that had been founded in 657 BC by Byzas, a Greek from Megara, as the new capital of his Empire. Finally, on Christmas Day, AD 800, when Charles, son of Pepin the Frank, was crowned by Pope Leo III as Emperor of Rome, it marked the political separation of the Western from the Eastern Roman Empire, which, by then, had become Greek in language and habits. With the Great Schism of 1054, the spiritual separation took place and the permanent estrangement of the two peoples was completed.

This brief historical overview of the Eastern Roman Empire that became known as “Byzantine”,<sup>2</sup> is important for us to realize that citizens in the East

<sup>1</sup> DEK: Type design can be hazardous to your interests. Once you get hooked, you will develop intense feelings about letterforms; the medium will intrude on the messages that you read. And you will perpetually be thinking of improvements to the fonts that you see everywhere, especially those of your own design.

<sup>2</sup> According to the Wikipedia Internet Encyclopedia (<http://en.wikipedia.org>):

The name “Byzantine Empire” is a modern term and would have appeared alien to its contemporaries. The term was invented in 1557, about a century after the fall of Constantinople (May 29, 1453) by German historian Hieronymus Wolf (ca. 1516–ca. 1580),

had a perception of life that was completely foreign to those in the West. As far as music is concerned, according to Christodoulos Halaris [4], a composer and researcher in ancient and medieval music:

... The ancient Greeks legated to the Byzantine both their musical philosophy and analytical music writing system they had invented. Thanks to the writings of Alupius, but also to Meibom who published in the 17th century the compiled works of ancient harmony writers, this system is to a great extent, readable in our times.

In the 4th century AD the ancient Greek music scripture system, whose symbols were derived from the ancient Greek and Ionian alphabets, is abandoned. A new system is born, which is also named “Parasemantics” but which, in contrast to the previous one, is of a clearly algorithmic nature. Its symbols do not denote tonal style, duration etc. but describe the behavior of the performer and, through it, the musical event to follow. As regards graphics, this system is inspired from the “pneumata” that define the pronunciation of words in the written form of the Greek language in Hellenistic times ...

This new system born in the 4th century AD may have had its symbols changed compared to the ancient ones, yet, the most important thing to remember is that there is an unaltered continuation of Greek music, both as a concept and more practically as scales and intervals, from ancient times,

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who introduced a system of Byzantine historiography in his work *Corpus Historiae Byzantinae* in order to distinguish ancient Roman from medieval Greek history without drawing attention to their ancient predecessors. Standardization of the term did not occur until the 17th century when French authors such as Montesquieu began to popularize it. Hieronymus himself was influenced by the rift caused by the 9th century dispute between Romans (Byzantines as we render them today) and Franks, who, under Charlemagne’s newly formed empire, and in concert with the Pope, attempted to legitimize their conquests by claiming inheritance of Roman rights in Italy, thereby renouncing their eastern neighbors as true Romans. The Donation of Constantine, one of the most famous forged documents in history, played a crucial rôle in this. Henceforth, it was fixed policy in the West to refer to the emperor in Constantinople not by the usual *Imperator Romanorum* (Emperor of the Romans) which was now reserved for the Frankish monarch, but as *Imperator Graecorum* (Emperor of the Greeks) and the land as *Imperium Graecorum*, *Graecia*, *Terra Graecorum* or even *Imperium Constantinopolitanus*.

For this reason the authors feel the need to restore truth by enclosing the term within “” throughout this article.

the Hellenistic period, on to the early Roman era, to “Byzantine” times, during the years of the Ottoman Empire, to this day.

Until the beginning of the 19th century, many laymen and church people tried to collect all the information on music notation and classify it in such a manner that would make it acceptable and easy to learn by all. Here we will not discuss details of the evolution of the “Byzantine” notation throughout the centuries; the interested reader will be able to find a detailed description of it on the web page of St. Anthony’s Greek Orthodox Monastery [6], Florence, AZ.

We do want to mention the great reformation that took place in 1814. The basic reformer was Metropolitan of Prussa, Chrysanthos of Madytos (ca. 1770–ca. 1840), who, along with the protopsaltes (chief cantor) Gregorios and the archivist Chourmouzios, made up the so-called “Three Teachers”. Basing their method on the Western sol-fa system, they invented the seven monosyllabic sounds according to the first seven letters of the Greek alphabet, facilitated the complex medieval neumatic notation and simplified the teaching of this art. Overall, what they accomplished was to shorten the teaching-learning process from ten years to ten months!

Having the blessing of the Ecumenical Patriarchate of Constantinople (today’s Istanbul, Turkey), they established their own school of music in 1815, thus making certified teachers to propagate this new method. Eventually, Chrysanthos wrote a book titled *Introduction to the theory and practice of ecclesiastical music written for the use of those studying according to the new method*, where he described the new system of teaching; the book was published in Paris in 1821. In 1832 he published the book *Great Theory of Music*, where a more detailed presentation and explanation of the new method is given.

### 3 A short introduction to the theory of “Byzantine” music

“Byzantine” music (BM) is the official ecclesiastical music of the Greek Orthodox Church, as well as being part of the folk traditions in Greece, Cyprus and anywhere else Greeks live. Other Eastern Orthodox Christians use Western notation and system for their liturgical needs. Thus, these melodies are more familiar to Western ears; the Hellenic (Greek<sup>3</sup>) musical notation system is a *Great Unknown*. Over the past century a host of people have tried to make BM more accessible to the West by transcribing “By-

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<sup>3</sup> The term “hellen” refers to Greeks who may not be citizens of the Greek state.

zantine” melodies into Western staff notation, yet, the result to an Eastern Orthodox has been acoustically very poor. This is because there are differences between the two musical systems that render them quite foreign to each other.

Next, we briefly discuss the most important features that differentiate the two systems. We hope that this brief discussion will provide a clue to the logic behind the structural method we followed for the design of the font series presented later.

First, as a general observation, we should make a reference to the opposing ways these two civilizations (Western and Hellenic) conceive the world. There is a deep gap between them, dating from the 2nd century BC, when the newly born Roman and the ancient Greek worlds met. Within the boundaries of the Roman Empire the clash over *Knowledge of Truth* broke out. The Greek understands Truth in *relation* with his fellow-men, he “... refuses to exhaust knowledge of the truth in its formulation...” [7], which is a fundamental concept in the Roman world. A Western mind does not like the idea of staying in the *description* of knowledge thus allowing for a free interpretation of it. It feels secure when it has an *absolute determination* of a concept which leaves no room for any other understanding. According to Prof. Christos Yannaras, there is a:

... refusal to exhaust knowledge of the truth in its formulation. The formulation is necessary and required, because it *defines* the truth, it separates and distinguishes it from every distortion and falsification of it... At the same time though, this formulation neither replaces nor exhausts the knowledge of the truth, which remains experiential and practical, a way of life and not a theoretical construction...

On the other hand, he claims that for the Western conception:

... The conventional logic of everyday understanding can very easily give man a false sense of a sure knowledge which, being won by the intellect, is already exhausted by it, completely possessed by it...

Just as the laws of justice fix the boundaries of the objective and effective assurance of social harmony, so also the definite, inescapably schematic—but commonly received—defining of truth assures the effective objectivity of knowledge and constitutes a kind of law of truth.

And so, for the first time in history, truth is identified with its formulation and knowledge

or the possession of truth with the individual understanding of this formulation. The truth is separated from the dynamic of life, it is identified with the concept, with right reasoning...

This differentiation in the perception of truth runs through all aspects of human life, from the legal system, governing of state, to the approaching of God and, of course, music.

After this general introduction, we can now see the most important differences between the two systems:

1. BM is strictly *monophonic*. *Polyphony* and *harmony*, which are the basis of Western music (WM), have no place in the Hellenic tradition.
2. Western notation is *absolute* and *determinative*, whereas “Byzantine” notation is *relative* and *descriptive*. To quote Prof. Demetrios Gianelos [3]:

A descriptive notation, such as that of Byzantine music, describes the essentials of the piece, leaving to oral tradition the task of completing with precision whatever is not described. On the contrary, a determinative form of writing, such as Western notation with staves, determines with great precision the manner of execution, to the point that the interpretation of the person executing it is delineated by factors that depend directly on the definitive indications of the music symbols. These indications can be absolutely restricting in that they preclude all room for interpretation.

In practice, the ...

... Western notation describes the melody in terms of absolute pitches whereas “Byzantine” notation describes the melody as relative pitches within a particular predefined scale... [6]

3. In a “Byzantine” melody the music has only one goal, to serve and emphasize the Word. This is not a characteristic only of the “Byzantine” tradition but it has spread over 5000 years of Greek history. The Word comes first and the music follows to stress the former, never the opposite; this rule is meticulously obeyed even in modern Greek popular music. To return to the “Byzantine” notation, every musical phrase is made up of two parallel lines: an upper line containing the quantity and the quality symbols and a lower line containing the syllables of the

C	D	E	F	G	A	B	C
200	167	133	200	133	233	133	
200	200	100	200	200	200	100	
C	D	E	F	G	A	B	C

**Figure 1:** Comparison between a typical Western (lower) and “Byzantine” (upper) scale

particular hymn, each syllable corresponding to one or more symbols. Thus, a BM font designer will have to take into consideration the distance between neighboring lines when deciding the dimensions of the bounding box that enclose an individual character, most especially its depth and height.

- To a Western ear a Greek melodic line seems foreign. This is because the intervals between the notes (the frequency that a note is higher or lower than its neighbor) in the two scales are different. To understand this let us introduce the two scales. The typical seven pitches of the Western scale are:

do, re, mi, fa, sol, la, ti

The seven pitches of a “Byzantine” scale have names that originate from the first seven letters of the Greek alphabet (A, B, Γ, Δ, E, Z, H) with a consonant prepended or a vowel appended to produce a sounded syllable; in other words:

πA    Βου    Γα    Δι    ϰE    Ζω    νH  
 (paa    voo    gaa    thee    ke    zo    nee)

The two sets coincide when:

D	re	↔	πA
E	mi	↔	Βου
F	fa	↔	Γα
G	sol	↔	Δι
A	la	↔	ϰE
B	ti	↔	Ζω
C	Do	↔	νH

Figure 1 compares the typical Western C major diatonic with the “Byzantine” soft chromatic scale. The distance between the two ends of the scale (from do to do’ or from C to the next C) is equal to 1200 cents. By inspection, one can see that the interval between D and E is 33 cents shorter and between E and F is 33 cents longer. The same interval difference exists between G and A, A and B and B and C. Any Western scale consists of whole and half intervals (200 cents and 100 cents, respectively); no other intervals are allowed. One can convert a

half interval into a whole and vice versa by making the end notes either sharp or flat. On the other hand, the typical “Byzantine” scale, besides having intervals other than 200 cents and 100 cents, as we see in fig. 1, one may sharpen or flatten a note to a non-Western pitch. Western notation is not adequate to cover all these individual cases.

- Both systems possess many qualitative marks that describe how a note or a group of notes should be chanted. The difference enters not through the symbols used by each system but through their semantics. Each system has its own definition of “quality” and this is mirrored in the symbols used. Since BM is strictly vocal, as we discussed before, the main goal of a potential composer is to stress the word. Traditionally, in the ancient Orthodox Church, the performance of a melodic phrase is accompanied by heavy gesturing (“neume” in Greek) by the cantor or the chorist (something that, unfortunately, has been abandoned by modern-day cantors). The quality marks, the neumes, would have to resemble the hand motion.

To give an example, **petastē** is a neume that bears both quantity and quality properties; it tells the cantor that upon ascending the scale between two neighboring pitches he will have to abruptly raise his voice. The shape of **petastē** resembles the trace of the fingertip as it moves from the lower up to the higher note with the abrupt voice raising taking place when closer to the latter.

Another example is the **psifistōn**. Its symmetrical shape shows the cantor that he will have to stress the syllable upon which the **psifiston** acts, as soon as he is on it and not before or after.

As mentioned previously, a scale is a series of seven pitches, either ascending or descending, with the two edges having distance equal to 1200 cents or the highest note having twice the frequency of the lowest. To make a scale all we need is to start with











Character	Name	Interval	Character	Name	Interval
	Ison	0		Ypselē	+4
	Oligon	+1		Apóstrophos	-1
	Petastē	+1		Elaphrón	-2
	Kentēmata	+1		Yporroē	-1 - 1
	Kéntēma	+2		Hamelē	-4

Table 1: The 10 quantity symbols of the “Byzantine” notation

a note, say Re (D), and ascend or descend till we reach the next higher or previous lower, Re´ or re, respectively.

Two kinds of scales are standard in Western music, majors and minors. The former have seven consecutive intervals of the form WWHWWWH (where “W” stands for a whole interval or 200 cents and H stands for a half interval or 100 cents), while the seven intervals of the latter have the form WHWWHWW.

In “Byzantine” music we can also make scales according to the Western analogy, but here we must introduce the idea of *mode*. The backbone of a mode is still a scale but the intervals do not remain the same ascending and descending. The entire melodic line seems to revolve around a note, and this note, called the “drone”, creates the foundation upon which the melody is built. Ancient Greek music had 15 such modes; ecclesiastical music kept only eight of those, deemed less secular and more suitable to the Church piety. The eight are split into four pairs, the regular and its “plagal” mode, the latter having a scale that starts four intervals higher or lower than the former. In the next section we further discuss the rôle of the modes in the “Byzantine” melody.

#### 4 Constituents of “Byzantine” notation

The basic notation used in “Byzantine” music uses ten marks, called *quantity* neumes. These characters with their names can be seen in table 1.

Also seen in the table are the intervals that the pitch should ascend (+) or descend (-) relative to the previous quantity character. The ‘Ison’ (0) character tells the cantor that he should move on to the next character without ascending or descending his pitch. To exemplify, Oligon asks for a 1-interval ascending, which means that if the previous character was on C the next to be pronounced should be D.

On the other hand, Yporroē asks for two consecutive descendings, e.g., if the previous character was on E, we should clearly pronounce D and C. Combinations of the 10 basic quantity symbols allow for ascending or descending a number of intervals other than the ones shown in table (1). For example, placing a Kéntēma over Oligon, as in:



represents three intervals ascending, whereas placing Apóstrophos under Hamelē, as in:



allows for six intervals descending.

Four pieces of information are needed before starting the chanting of a piece:

- Based on the relativism of “Byzantine” music, each character does not exist on its own but in connection with its previous neighbor (unlike Western notation, where a note is perfectly known from its position on the staff). The name, that is, C, D, etc., of the very first character is known with the help of a clef symbol known as *Martyrēa*. The word “martyrō” in Greek means to bear witness. In other words, *Martyrēa* tells the cantor what is the very first character of the melodic piece.
- The cantor needs to know how he should chant the particular character he is on: whether he should stress or lower his voice, do a short trembling, etc. The symbols bearing this kind of information are called *quality* marks and there are six of them, shown in table 2.
- The cantor needs to know how long he should spend on each syllable. The time characters, shown in table 3, provide this kind of information, given a unit of time or tempo. Table 4 shows the six possible tempos along with their







Character	Definition	Name	Quality Action
	<code>\ank</code>	Antikénoma	Short jerking of the voice
	<code>\ank</code>	Varēa	Chanting in a base manner
	<code>\ank</code>	Endófonon	Humming
	<code>\ank</code>	Eteron	Connecting same quantity characters
	<code>\oml</code>	Omalón	Waving the voice in a trembling manner
	<code>\oml</code>	Psēphistón	Stressing the specific vowel

Table 2: The 6 quality characters of the “Byzantine” notation














Character	Definition	Name	Action
	<code>\kla</code>	Klásma	2× the unit of time
		Aplē	2× the unit of time
		Diplē	3× the unit of time
		Triplē	4× the unit of time
	<code>\grg</code>	Gorgón	1/2× the unit of time
	<code>\dgrg</code>	Dēgorgón	1/3× the unit of time
	<code>\tgrg</code>	Trēgorgón	1/4× the unit of time
	<code>\arg</code>	Argón	3/2× the unit of time
	<code>\darg</code>	Dēargon	5/2× the unit of time
	<code>\targ</code>	Trēargon	7/2× the unit of time
	<code>\stav</code>	Stavrós	Pause to breathe
	<code>\paf</code>	Páfsis	Pause for the unit of time
	<code>\kor</code>	Koronēda	Pronouncing for unlimited time

Table 3: The 12 time characters of the “Byzantine” notation

Western counterparts, the calligraphic  $\chi$  being the first letter of the word “time” in Greek ( $\chi\rho\acute{o}\nu\omicron\varsigma$ ). If there are no time marks then the normal tempo is assumed.

- [d] Finally, the cantor needs to know the *mode* according to which he chants the specific hymn. As mentioned earlier, there are eight modes appropriate for the liturgical needs of the Orthodox Church. Table 5 shows symbols for all eight of them, along with their names and their *martyrēes*.

Also as mentioned previously, “Byzantine” music is strictly vocal and monophonic. The music notation always goes hand-in-hand with the words of the hymn. Nowhere will one find music notation on its own. The exercises made especially for “Byzantine” music students are written according to the sol-fa

system, whereas, special pieces, called “kratēmata”, written for practicing reasons, use meaningless syllables like **te**, **ta**, **rē**, **rem**, that help the cantor demonstrate his vocal skills.<sup>4</sup>

Every musical phrase consists of two lines, one above the other. The first line contains the musical symbols whereas the second line contains the syllables of the hymn to be chanted; each syllable corresponding to one or more symbols should be placed exactly under it, so there is no room for doubt as to the correspondence between symbols and syllables. As far as typesetting is concerned, this is a typical alignment problem which can be solved in  $\text{\LaTeX}$

<sup>4</sup> Given what we have seen so far, it will be understandable that this kind of showing off is not part of the liturgical music. Chanters do “kratēmata” only outside the church and in secular “Byzantine” concerts.







Tempo Symbol	Beats/minute	Action	Western symbol
	130	Normal	Andante
	168–208	Fast	Allegro
	> 208	Very fast	Presto or Prestissimo
	100–168	Moderate	Moderato
	80–100	Slow	Lento or Adagio
	56–80	Very slow	Grave or Largo

Table 4: The 6 tempo characters of the “Byzantine” notation









Martyrēa	Mode Name	Martyrēa	Mode Name
 ϰ Πα	First	 λ ϰ Πα	First Plagal
 ϰ Δι	Second	 λ ϰ Πα	Second Plagal
 ϰ	Third	 λ Ζω	Grave
 ϰ Δι	Fourth	 λ ϰ νη	Fourth Plagal

Table 5: The 8 modes of the “Byzantine” music

with the *tabular* environment. We turn now to such typesetting issues.

## 5 Typesetting

The user starts by opening a L<sup>A</sup>T<sub>E</sub>X document along the lines of the following sample:

```
\documentclass[12pt]{article}
```

```
\usepackage[greek,english]{babel}
```

```
\usepackage{longtable}
```

```
\usepackage{fullpage}
```

```
\usepackage{byzfonts}
```

```
\begin{document}
```

The standard *babel* package for multi-lingual support, with the *greek* and the *english* options, is necessary since the characters were designed to be used in a purely Greek environment; the `\wg` macro can be used when Greek environment is mingled with English. Next, a 16-column tabular environment with no vertical or horizontal rules is required for the basic layout. David Carlisle’s *longtable* pack-

age is used to typeset tables that cover more than one page, which is exactly what we would like to do here. We have found that, due to the larger size of the music characters compared to the letters under them and for readability purposes, 16 characters per line in the *fullsize* page environment is the optimum selection.

For the body of the document, the user types the 16 musical characters and, on the following line, he types the 16 syllables. Sometimes he types a *pause* mark, a *diastolē* (a vertical line that separates different time rhythms), an empty space or something other than a syllable.

The appendix shows the L<sup>A</sup>T<sub>E</sub>X code for an example psalm using the ByZ<sup>I</sup>L<sup>A</sup>T<sub>E</sub>X package, along with the corresponding output. We describe some of the package details next.

While struggling with the onomatopoeia for the macros of the individual glyphs, we decided to keep the traditional names for the ten basic quantity characters as well as for a few other simple neumes, for instance, `\iso` and `\apo`. As for the rest, we fol-

lowed a simple mnemonic rule: every character possesses a particular place in the font tables, given by its numerical position (from 0 to 255 in the decimal system, 000 to 377 in octal, or 00 to FF in hexadecimal). Every glyph is given a 3-letter macro name corresponding to its position in the font table as an octal number, according to this simple mapping:

0 ↔ o    1 ↔ a    2 ↔ b    3 ↔ c  
4 ↔ d    5 ↔ e    6 ↔ f    7 ↔ g

Thus, the glyph found at position 056 octal is represented by `\oef`.

Since the number of character combinations is greater than 256, we needed two font sets, which we named *byzf* and *byyf*. To access glyphs from either font, we prepend each character’s macro name with `\z` for characters taken from *byzf* or `\y` for characters belonging to *byyf*, to select the given font.

We also designed a third font, called *blal*, that contains the following. [a] A series of capital calligraphic letters with height equal to the distance between neighboring baselines, so that they can be used in the place of the first letter of the first word of a melodic phrase. [b] A series of small calligraphic letters, similar to those found in original “Byzantine” codes at the Athonite Monasteries. [c] A series of ligatures.

To access these characters without conflicting with the macro names of the two previous font series, we followed a different approach. Each character is given a 3-letter macro name, as before, but now the previous mapping is replaced by:

0 ↔ (z)ero    1 ↔ (o)ne    2 ↔ (t)wo  
3 ↔ th(r)ee    4 ↔ (f)our    5 ↔ f(i)ve  
6 ↔ si(x)    7 ↔ se(v)en

Thus, the character at octal 105 will be accessed by `\ozi`. Prepending the `\f` macro to indicate the *blal* font, glyph oct105 is represented by `\f\ozi`. Of course the calligraphy letters are accessed by just putting `\f` in front of the letter, as in `\f B`.

Finally, to include a “Byzantine” font character in a sentence, of course the font switch must be enclosed in a group, as in `{\f\ozi}`.

## 6 Conclusion

Using Donald Knuth’s METAFONT we have designed *almost* all the glyphs (quantity and quality neumes, tempo characters, sharp and flat marks, as well as a series of letters and ligatures) used in the “Byzantine” music (the music of the Greek Orthodox Church and of Greek folk songs and dances). We also constructed the  $\mathcal{B}\mathcal{Y}\mathcal{Z}$ -L<sup>A</sup>T<sub>E</sub>X package employing the L<sup>A</sup>T<sub>E</sub>X’s *tabular* environment for typesetting nice music phrases.

One shortcoming of the package is the lack of a method for users to make character combinations from existing simple ones. This is the reason we emphasized the word “almost” above. We meant the combinations that came to our knowledge by the time of this article. For complex characters not found in the tables the user will either have to design them from scratch (using METAFONT) or contact the authors.

## 7 Acknowledgments

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Appendix

**Ⲅ** L<sup>A</sup>T<sub>E</sub>X code and output for Psalm 102: Excerpts in the Plagal Fourth mode. Adapted from the traditional Athonite melody as written by Hieromonk Hierotheos of Philotheou Monastery and translated from Greek by the monks of St. Anthony’s Monastery, Florence, AZ.

```

\setlongtables
\begin{longtable}{*{16}{@{\extracolsep{\fill}}c}}
&&& \multicolumn{10}{c}{Plagal 4th mode \wg{\pDHXOC}} &&& \TAX{200}\
&&&&&&&&&&&&&&&&&&& \f\OBO\
&&&&&&&&&&&&&&&&&&& \f\OBO\
& \y\zxo & \z\iso & \z\cag & \z\apo & \z\oli & \z\zxx & \y\zvi &
\z\iso & \z\apo & \z\oli & \z\bgf & \z\apo & \z\cde & \f\OBO & \z\agb \
{\f B} & less & the & Lord & O & my & soul & bless &
- & ed & art & Thou & O & Lord & & Bless \
& \z\iso & \z\apo & \z\knt & \z\bgf & \z\apo & \z\apo & \z\iso & \y\zxi &
\z\apo & \z\apo & \z\dst & \z\oli & \z\oli & \z\afO & \z\aoa & \z\adb \
the & Lord & - & O & my & soul & and & all & &
- & that & & is & with & in & me & bless \
& \z\apo & \z\apo & \z\apo & \z\cdg & \z\paf &&&&&&&&&&&&& \f\OBO \
His & Ho & ly & Name &&&&&&&&&&&&&&&&&&& \
& \z\agb & \z\iso & \z\apo & \z\knt & \z\bgf & \z\apo & \z\cde &
& \f\OBA & \z\apo & \z\iso & \z\oli & \z\knt & \y\zxx & \z\bgf & \z\apo \
{\f B} & less & the & Lord & - & O & my & soul &
& and & for & get & - & not & all & that \
& \z\apo & \z\apo & \z\afO & \z\ela & \z\dst & \z\acc & \z\paf & &
& & & & & & & & & \f\OBO \
He & hath & done & for & & & & & & \f\OBO \
%&&&&&&&&&&&&&&&&&&&&&&&&& \
\end{tabular}

```