The Diatonic Scale in Greek Orthodox Church Music

Most musicologists assume that medieval Byzantine chant, i.e. the Greek Orthodox sacred music before the fall of Constantinople in 1453, was purely diatonic and made use of Pythagorean tuning. But what happened afterwards, when Greece came under Ottoman rule? After 1453 Greek Orthodox music gradually changed. The same poetical texts remained in use, but the music underwent the influence of Turkish music and was affected by its 'oriental' tonality.

The following factors may have played a role. Late Byzantine chant was composed in a highly melismatic and ornate style and had consequently developed a notation so complicated (with c. 60 signs!) that soon after 1453 it became unmanageable. Consequently oral tradition and improvisation grew in importance, with all the uncertainties inherent thereto. Further, Constantinople, where the patriarch was seated, dependent from and in close connection with the Ottoman rulers, gained an ever growing significance for the Greek Orthodox people. The musical tradition of the "Great Church", the church of the patriarchate, became dominant. Thus cultural exchange certainly led to the occurrence of the 'oriental' tonality in the compositions of leading 18th century composers in the Ottoman capital. The most important of these is the great composer Petros Lampadarios (ca. 1730-1777), who improved the notation system and undertook the task to compose the music of church offices in a plain style. His output constitutes the main body of Greek Orthodox music today. In 1814, Chrysanthos of Madytos developed a new system of notation, which is still in use in Greece. Through transcription to this system, the music of Lampadarios, his contemporaries and his successors are preserved till the present day.

In an excurse in the second edition of *A History of Byzantine Music and Hymnography*, Oxford, 1961, Egon Wellesz also gives his opinion that a "transformation of the old Byzantine tonality took place under Turkish influence" (p. 366). He undoubtly has in mind that, beside the diatonic tonality, modern Greek Orthodox chant makes use also of a 'chromatic' tonality. However, as is shown to be probable below, the diatonic tonality of modern Greek chant was originally an 'oriental' tonality as well. This can be made clear by consulting the famous book of Chrysanthos of Madytos, *Μέγα Θεωρητικὸν τῆς Μουσικῆς*, Trieste, 1832.

The following provides a preliminary understanding. In 1881 a musical committee, which met in Constantinople, defined a system of interval measuring which divided the octave into 72 interval units called 'moria', sg. 'morion'. A musical interval can then be given in two ways: 1) as a ratio of the frequencies of the tones of that interval, and 2) as a number that indicates how many moria that interval contains. For a perfect fifth, then, the ratio of the frequencies of the tones is 3/2, and a perfect fifth contains 42.12 moria[1]. Now the frequency ratio of the tones of an interval is the reverse of the ratio of the lengths of the sounding parts of a string giving that interval. So, in order to get a tone a perfect fifth higher than the tone produced by the whole string, the vibrating part of the string must be made 2/3 of the whole string length, since the ratio of the pitches of the high tone and low tone of a perfect fifth is 3/2.

In his 'diatonic' scale, Pa[d] Bou[e] Ga[f] Di[g] Ke[a] Zo[b] Ne[c] Pa[d], Chrysanthos distinguishes three kinds of tones: the major tones Ga-Di[f-g], Di-Ke[g-a] and Ne-Pa[c-d], the minor tones Pa-Bou[d-e] and Ke-Zo[a-b] and the 'minimum' tones Bou-Ga[e-f] and Zo-Ne[b-c] (§ 54).

Chrysanthos precisely determines (in § 63) where to place the frets on a pandouris (a great bass cistre with a Di[G]-, a Ga[F]- and a Pa[D]-string, tuned in the diatonic scale). He then correctly concludes (in § 65) that each ratio of the sounding part of a string to the whole length of the string for each different tone is:

1	8/9	22/27	3/4	2/3	11/18	9/16	1/2
Di	Ke	Zo	Ne	Pa	Bou	Ga	Di

Thus the ratio of the frequecy of each tone to the frequency of the fundamental tone is:

1	9/8	27/22	4/3	3/2	18/11	16/9	2
G	a	b	c	d	e	f	g

And the ratio of the frequencies of the tones of each successive interval is:

	9/8		12/11		88/81		9/8		12/11		88/81		9/8	
G		a		b		c		d		e		f		g

Then the number of moria of each tone is:

0	12.23	21.27	29.88	42.12	51.16	59.77	72
G	a	b	c	d	e	f	g

And the number of moria in each successive interval is:

	12.23		9.04		8.61		12.23		9.04		8.61		12.23	
G		a		b		c		d		e		f		g

These numbers correspond approximately to:

	12		9		9		12		9		9		12	
G		a		b		c		d		e		f		g

Or, to give them in tones:

	1		¾		¾		1		¾		¾		1	
G		a		b		c		d		e		f		g

This scale is not at all diatonic like in modern Byzantine music, but purely Arabic or Turkish, where its three-quarter tone is characteristic. The tetrachords c-d-e-f and g-a-b-c equal the Rast tetrachord whose intervals are 1 ¾ ¾, and the tetrachords d-e-f-g and a-b-c-d equal the Bayati tetrachord whose intervals are ¾ ¾ 1, two of the most common sounds in Arabic music. This corresponds with Chrysanthos' remark, "our diatonic genus is different from that of the Ancient Greeks and the Europeans" (§ 217 note 1).

The 'chromatic' scales, still in use in modern Byzantine music, with their characteristic one-and-a-half tone are also purely Arabic or Turkish. There we have to do with the Hijaz tetrachord, ½ 1½ ½, also one of the most common sounds in Arabic music. It appears then that Byzantine music had become completely orientalized in its scales.

Unfortunately Chrysanthos gives the wrong numbers for the tones of the ‘diatonic’ genus (§ 63 note 2). He repeatedly mentions that the major tone, the minor tone and the ‘minimal’ tone have the ratio 12, 9, 7 with respect to each other. Clearly Chrysanthos did not have any notion of logarithms. In fact, if the major tone is given the number 12, the ratio is 12, 8.86, 8.44[2].

Considering the nonsensical numbers 12, 9 and 7 for the tones of the diatonic genus, one must also mistrust the numbers Chrysanthos gives for the ‘enharmonic’ and ‘chromatic’ genera. For these he doesn’t give the placing of the frets and the shortening of the strings, such as for his diatonic genus. The numbers Chrysanthos gives for the chromatic genus are a clear example of error:

	7		12		7		12		7		12		7	
D		E		F		G		a		b		c		d

Here E-F and b-c, which have to be augmented tones, have the same number of interval units as the major tone in his ‘diatonic’ genus. Moreover, the octave here has 64 interval units instead of 68 in the other cases. These numbers were later corrected by others[3]:

	7		14		7		12		7		14		7	
D		E		F		G		a		b		c		d

Chrysanthos’ numbers 12, 9 and 7 for the tones in the ‘diatonic’ genus remained unaltered till 1881. At that time the aforementioned musical committee defined the diatonic scale – later called the *‘soft diatonic scale’*[4] – anew, giving the major tone 12 moria, the minor tone 10 moria, and the minimum tone 8 moria. This scale has some resemblance with the western diatonic scale in just intonation, where the two different major seconds and the minor second have the frequency ratios 9/8, 10/9 and 16/15. In terms of moria: 12.23, 10.94 and 6.70. If just intonation was intended, it would have been better to assign the major tone 12, the minor tone 11 and the minimum tone 7 moria. For a pure major third of 23.18 moria, an approximate major third 12 + 10 = 22 is too small, but the major third 12 + 11 = 23 is close to perfect.

Moreover an ‘enharmonic’ scale was also defined – later called *‘hard diatonic scale’*[4] – with 12 moria for the whole tones and 6 moria for the semitones. This scale is in fact identical with the western diatonic scale in equal temperament. This scale approaches the Pythagorean scale, where all major seconds have the vibration ratio 9/8 and the minor second the frequency ratio 256/243, in moria 12.23 and 5.41.

In my opinion the difference between the soft diatonic and hard diatonic genera is purely theoretical. In monophonic vocal music the pitches are not so stable as in other genres of music. They may vary from purely *Pythagorean tuning* (hard diatonic?) to more or less *just intonation* (soft diatonic?), according with the intended musical expression of the text or in relation with a existing drone on the base tone. Hearing Greek cantors singing provides affirmation of this hypothesis.

Contrary to the expectation of many Greeks, the tonalities used in modern Greek Orthodox church music have no direct equivalence to the tonality that was used in the older Byzantine rite. There is no uninterrupted tradition from the chant of the Byzantine Empire to the chant of the Greeks today. In the course of the Ottoman period the traditional texts received new melodies in ‘oriental’ tonality, which contained either 1½ tones (‘chromatic’ tonality), or ¾ tones (‘diatonic’ tonality).

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[1] If an interval has a frequency ratio f, then its value n in moria is, in the modern Greek system:

$$n = 72 \ \frac{\log f}{\log 2}$$

[2] If one interval has a frequency ratio f and another interval the frequency ratio g, then the numbers of their interval units have the ratio $\log f : \log g$. Thus, given the interval 9/8 has 12 interval units, the interval 12/11 then has $\frac{\log 12/11}{\log 9/8} \cdot 12 = 8.86$ interval units, and the interval 88/81 has $\frac{\log 88/81}{\log 9/8} \cdot 12 = 8.44$ interval units.

[3] See Christ / Paranikas, 1871, p. cxxii.

[4] See Σίμων Καράς, 1982. The new, more accurate terminology, has not been fully adopted everywhere.

Appendix: Chrysanthos’ erroneous calculations

In § 63 note 2 Chrysanthos announces: “Here below is proved that the intervals di-ke [G-a], ke-zo [a-b] and zo-ne [b-c] have to each other the ratios such as 12, 9, 7”.

To ‘prove’ this he assumes that on the G-string of a pandouris the interval of the major tone G-a has 12 length units. Because in § 63 the a-fret was found by shortening the G-string in the ratio 8/9, the length of the whole string is 108:

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   1    :                         8                                    8/9 · 108 = 96
|--------|-----------------------------------------------------------------|      108 – 96 = 12
   12                            96
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Instead of giving Chrysanthos’ rather clumsy calculations here, I will follow these with the help of diagrams, in the hope of so giving a clearer insight into the errors which he made.

Firstly he tries to find the ratio of the major tone G-a and the minor tone a-b. Since in § 63 the b-fret for a minor tone a-b was found by shortening the string length with 11/12, he now shortens the whole string with 11/12:

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    1  :                          11                                   11/12 · 108 = 99
 |------|-------------------------------------------------------------------|      108 – 99 = 9
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9 99

Then he states that when the major tone has 12 interval units, the minor tone then has 9 interval units. This is *wrong* because an interval unit, progressing along the string, becomes continuously smaller. In fact the minor tone has 8.86 interval units, as is said above.

Secondly he finds the ratio of the major tone G-a and the minim tone b-c. The fret for the tone c is determined by shortening the whole string with 3/4:

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        1          :                        3                              3/4 · 108 = 81
 |-----------------|--------------------------------------------------|    108 – 81 = 27
       27                                   81
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The fret for the tone b is found by shortening the whole string with 22/27:

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       5       :                         22                                22/27 · 108 = 88
 |-------------|------------------------------------------------------|    108 – 88 = 20
      20                                 88
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So the distance of b-c on the G-string is 27 – 20 = 7. Then Chrysanthos states that when the major tone has 12 interval units, the minim tone has 7 interval units. This is *altogether wrong*, because further down on a string the distance between frets giving a specific interval becomes proportionally smaller.

When Chrysanthos has calculated the minim tone as he did with the minor tone, comparing the distance of the minim tone on the whole string with the major tone on the whole string, he would have found the number 7/88 · 108 = 8.59. In fact the minim tone has 8.44 interval units, as is said above.

Chrysanthos' error is the more incomprehensible because in § 64 he is fully aware that for the same interval an octave higher, the distance of the frets must be halved. Why didn't he take into account that also within an octave the same interval on a higher place get a smaller fret distance?

See the diagram below, where all the tones of Chrysanthos' diatonic scale from G to g are given on a string with 108 length units. There we see that the distance 9 on the string for the major tone c-d, a fourth higher than the major tone G-a, is 3/4 of the distance 12 on the string for the major tone G-a, 3/4 being the shortening of a string to get a fourth. The same is true for the minor tones a-b and d-e and the minimum tones b-c and e-f.

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    12     8    7    9     6  5¼ 6¾                 54
  |--------|-----|----|------|----|---|----|-----------------------------------|
 G         a    b    c      d    e   f    g
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