Brain and Sound Resonance

The World of Self-Generative Functions as a Basis of the Spectral Language of Music

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ABSTRACT: The author discusses the "preferential phenomenology" of sound spectra. Most interesting have been the sound relations that result from special filtering according to "rings" of resonance. Mathematical operations are required to describe this filtering of frequency multiples—spectral components—producing sum and difference tones. With new harmonic formats, a new phenomenological vocabulary of music is achieved that evolves far beyond its historical language.

KEYWORDS: brain; sound resonance; spectral language; music

INTRODUCTION

Since 1969, I have worked on what I term the "preferential phenomenology" of sound spectra. Most interesting have been sound relations that result from special filtering according to "rings" of resonance. Mathematical operations are required to describe this filtering of frequency multiples—spectral components—producing sum and difference tones (which are also multiples of the same fundamental, that is, they belong to the same spectrum).

Given that a ring modulation of frequency is perceived by our brain in a condition of high intensity (e.g., we hear four pitches while playing only two), we can emancipate these virtual functions, even at low dynamics, and make them, for musical reasons, into "real" pitches. Thus, we arrive at completely unfamiliar simultaneous pitch functions (formants), resulting from specific spectral self-generative processes. For example, primal functions 4 and 7 produce in sum 11 and in difference 3; primal functions 16 and 21 produce in sum 37 and in difference 5.

If this type of self-generation, using both sums and differences of frequencies, is proved to exist in both the acoustic and the perceptual domain, a more specific self-generative behavior of sounds based on the multiplication of the multiples is acous-

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tically possible, but has not yet been demonstrated as a common situation in the field of brain resonance. For example, bispectrality, that is, when harmonics 7 and 11 produce 77, can both be virtual fundamentals. With these harmonic formats, issuing from both sound resonance and brain resonance, we achieve a new phenomenological vocabulary of music, which evolves far beyond its historical language.

EXPLICIT SPECTRA OF A COMPACT ROW OF FUNCTIONS

One of the oldest scores to use the spectral technique is *Credo,* op. 10 (Paris, 1969) for nine celli, in which a compact spectrum of 45 theoretical harmonics of the cello's low C become the new fundamentals of 4170 micromusic events evolving over a duration of 55 minutes. The logarithmically unequal intervals in between these 45 are used over a range from low C_0 to a high F#.[4] (Throughout this paper, I use the German system of octave numbering.) These new spectrally organized pitches are stable plateaus of frequency, fundamentals of a new mode of 45 microtonal pitches; in other words, the 45 harmonics of low C_0 (64 Hz) have become new fundamentals for a random "spectrum pulse" orchestrated in 4170 "micro-volcanoes" of timbral processes. This process of treating what were formerly considered harmonics as "real" pitches I call the "emanation of the immanence."

The nine celli "read" a "fresco" score of nine macro-music large structures: α, β, γ, δ, ε, λ, τ, ϕ, and ω. Each of these large nine macro-music structures is built on an ever-increasing number of new fundamentals (corresponding to "ex"-harmonics 1 to 45):

> α on 1, β on 2 and 3, γ on 4, 5 and 6, δ on 7, 8, 9 and 10, and so on, until ω on 37, 38, 39, 40, 41, 42, 43, 44 and 45.

The first cello plays nine macro-music structures in 55 minutes:

τ β ε δ λ α γ ω ϕ

Simultaneously, the second cello plays only eight in retrograde order; they are dilated in time:

β τ ϕ ω γ α λ δ

The third cello plays seven macro-music structures again in direct order:

ϕ τ β ε δ λ α

and so on, until the ninth cello, which plays only one macro-music during the whole 55 minutes:

w

Thus, the odd-numbered celli perform in direct movement and the even-numbered in retrograde movement. These multiple layers of music result from the gradual loss of specific macro-musics, and the dilation in time of the others that are performed simultaneously. The whole resembles the "reading" of a fresco from nine distances at the same time by nine celli; for the odd-numbered celli time runs from left to right, and for the even-numbered celli from right to left (i.e., simultaneously "direct" and "reversed" time).

The "chorale" of macro-music structures containing the 4170 micromusic events reaches a climax of only eight, as the maximum of the simultaneous different macro-music structures, the vertical density of nine being felt only as a premonition or a remembrance, since the missing ninth macro-music exists in the previous macro-form column or will appear in the next column (FIG. 1, macroform of *Credo*; FIG. 2, Processing Matrix). Intuitively, this is perceived as the "Divine Ninth Heaven," never to be reached by Man. The subconscious, conscious, and hyperconscious "floating"' within the Primal Chord of 45 different pitches (from which 23 are totally unique–the 23 odd harmonics) gives us the impression of a cosmic chord of Beginning and Ending, reminding us of the words of Guillaume de Machaut, "ma Fin est mon Commencement" (c.1364).

An Explicit Compact Spectrum as the Modus of "New Fundamentals" against Implicit Spectra Projected by False Fundamentals (with a Simultaneous Upper Cluster of Harmonics 28-65)

A Doini, op. 24α (1974) and *Alt A Doini,* op. 24β (1980) for 17 players with *sound icons (*vertical grand pianos bowed with rosined threads). The piano strings are retuned according to a "spectral scordatura." The principal compact zone covers a range of a twelfth, from harmonic 8 to harmonic 24 for version α, and of two and a half octaves for version β, from harmonic 6 to harmonic 33 (17 unique harmonics, with no repetition at octaves). The score symbols are micromusic processes, combining Jung's compass of the psyche (thought-feeling-intuition-sensation) with my 'sound plasma' compass: noise-sound-element-width (FIG. 3, matrix score of *Alt A Doini*; FIGS. 4, 5, and 6, performance symbols). If the principal zone has a fundamental of B natural (*A Doini*), the false virtual fundamentals are A, B flat, and C. The principal zone covers the same range as the interval between harmonics 1 and 3, that is, the interval between a fundamental and its first "new" harmonic, which is now filled by the scale of theoretical harmonics 8 to 24. The three "crude" implicit spectra of the false fundamentals fight against the explicit spectrum of B. The four spectra "shadow" one another, being slightly apart from each other in pitch but all "acting" in the same register.

Similar explicit compact spectra, harmonics 7 to 26 and 27 to 113, are set in opposition against an "inverse" spectrum, from harmonic 1 to –333, in *Thirteen Dreams Ago,* op. 26 (1978) for 33 strings (3 × 11), the higher group and the very low group of strings using spectral scordatura.

A special "galactic" uphill of spectral functions (7 to 57) is deployed in the evolution of the 139 micromusic events in *Ecou Atins* [e′kou a′tins], *Touched Echo* (1979). Bass flute (and grand flute), horn, soprano, cello, sound icon, and 29 bowed and spectrally tuned monochords figurate a "chorale" on the resonance of an E, where the "emanation of the immanence" renders the sound sources quite indistinguishable by increasing the spectral energy of the stable frequency-plateaus. We confuse them and mistake one for the other (FIGS. 7 and 8, score pages on colored slides). Related is the slow "chorale," of 24 minutes, also on an E spectrum, in *Frenetico il longing di amare,* op. 56 (1985), where bass voice, contrabass flute, and sound icon exchange elements of that spectrum to form special chords, mostly compact formants evolving as "expanding constellations."

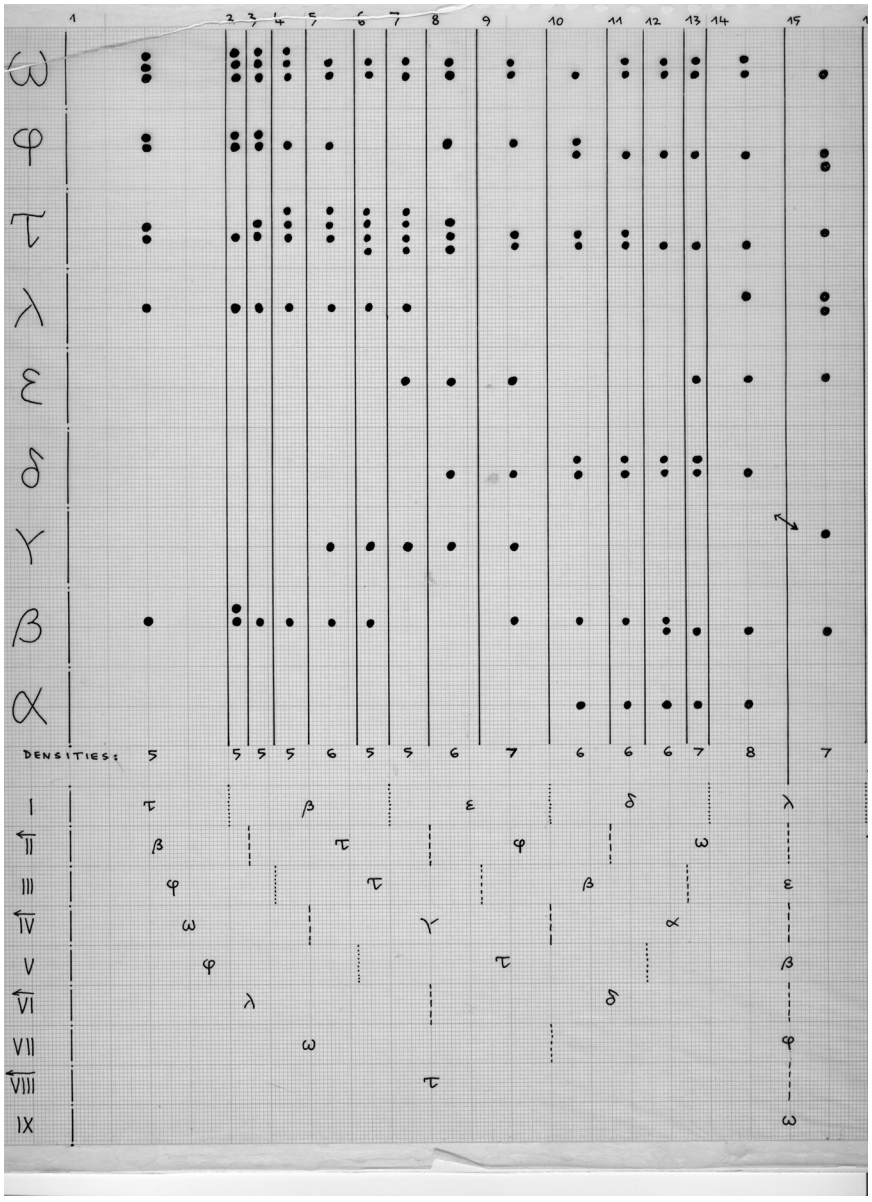


FIGURE 1.

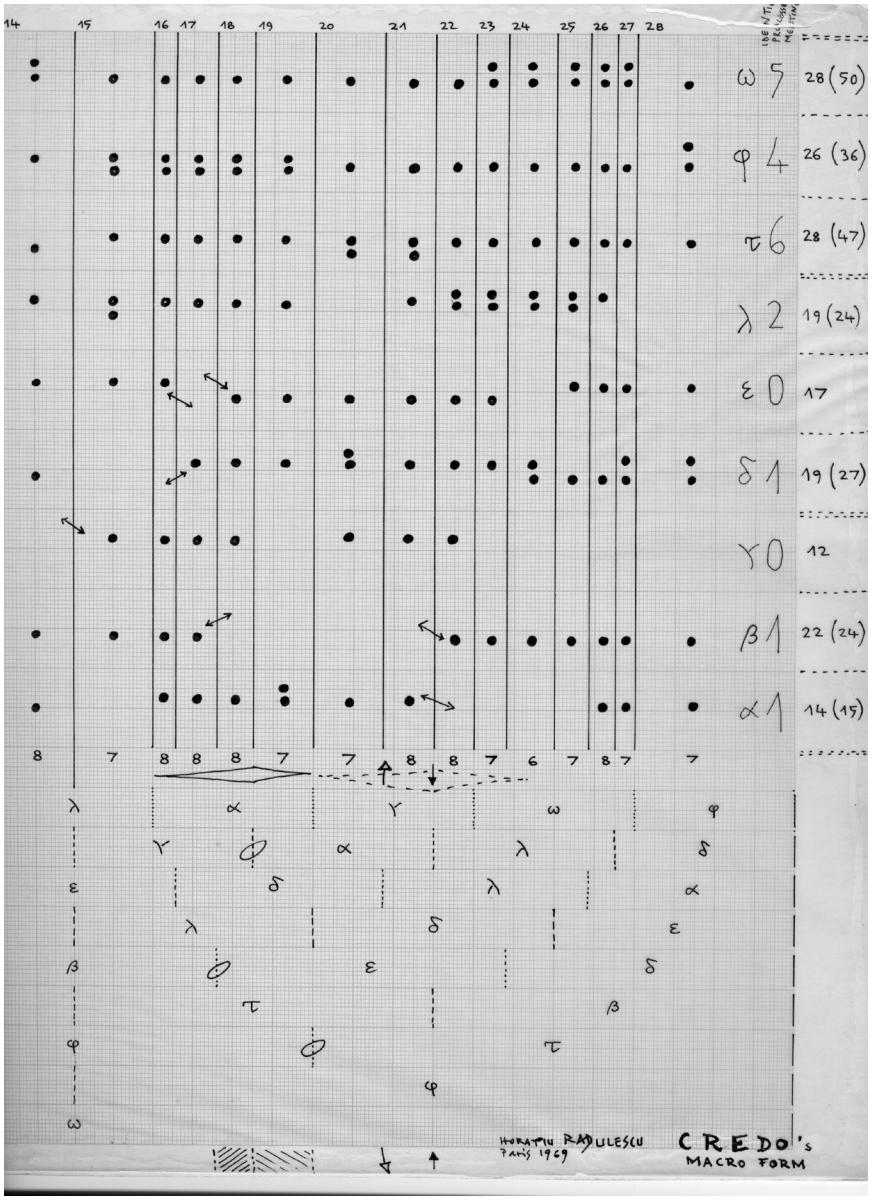

14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
28 (50)
26 (36)
28 (47)
19 (24)
17
19 (27)
12
22 (24)
14 (15)
HORATIU RADULESCU
Paris 1969
CREDO's
MACRO FORM

FIGURE 2.

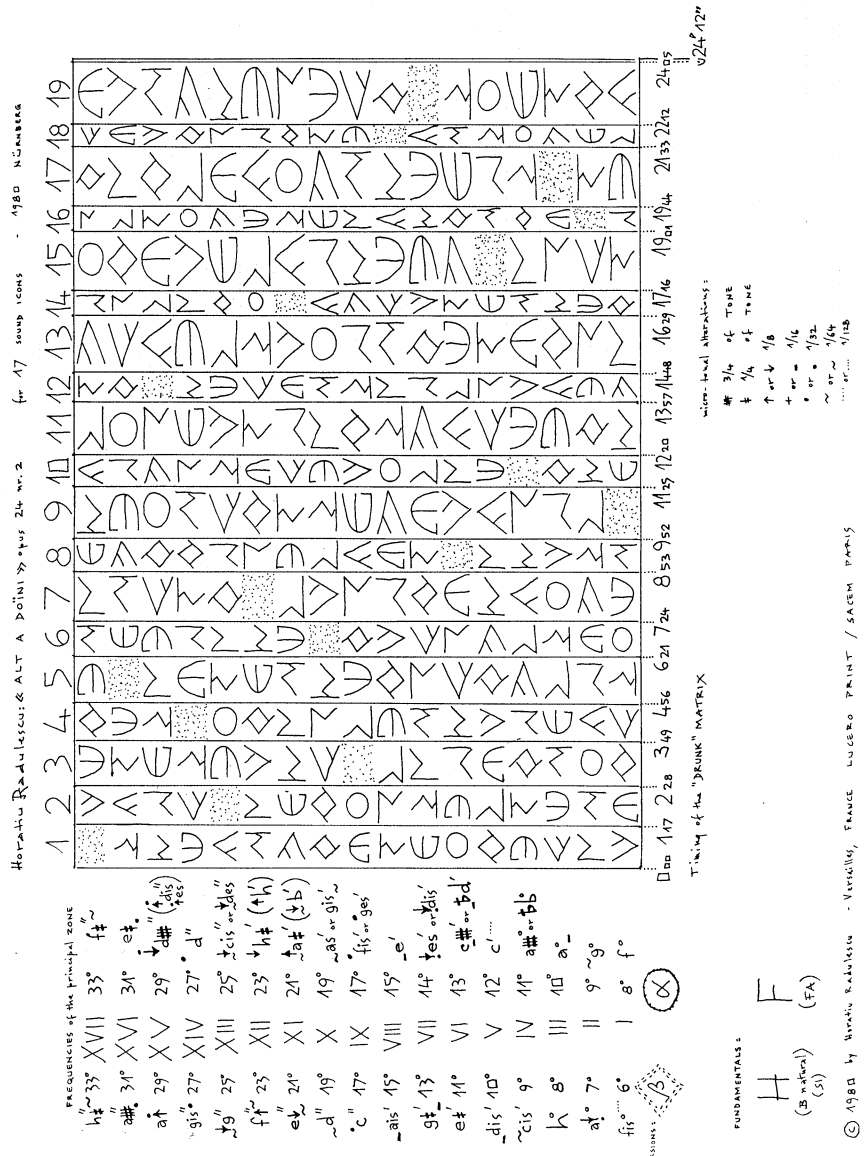
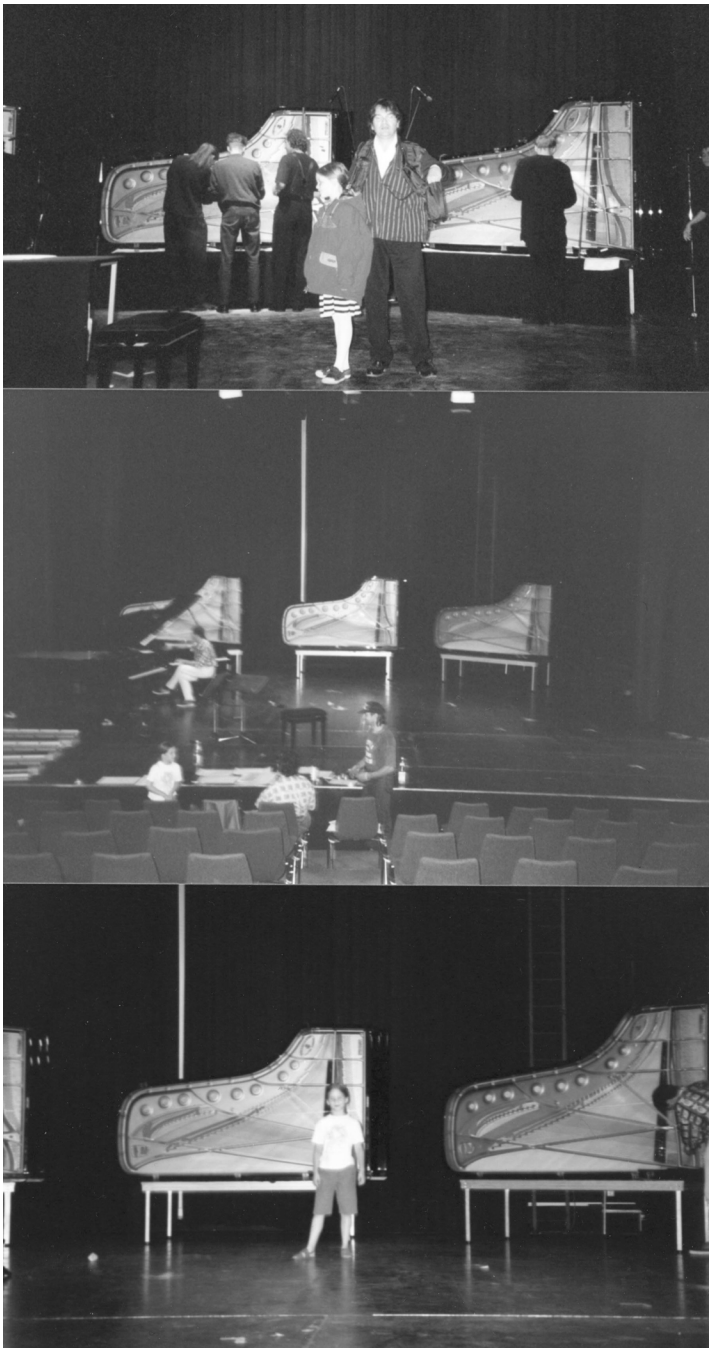

Horatiu Radulescu & Alt a Doini Symus 24 nr. 2
for 17 sound icons - 1980 Nürnberg
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/17 2/28 3/49 4/56 6/21 7/24 8/53 9/52 11/25 12/20 13/57/1448 16/29 17/46 19/24 19/44 21/33 22/12 24/05
Timing of the "drunk" matrix
FREQUENCIES of the principal zone
FUNDAMENTALS:
(B natural) (Si)
(FA)
VERSIONS:
micro-tonal alterations:
3/4 of tone
1/4 of tone
1/8
1/16
1/32
1/64
1/128
© 1980 by Horatiu Radulescu - Versailles, France - Lugero Print / Salem Mass

FIGURE 3.



FIGURES 4 (top), 5 (middle), and 6 (bottom).

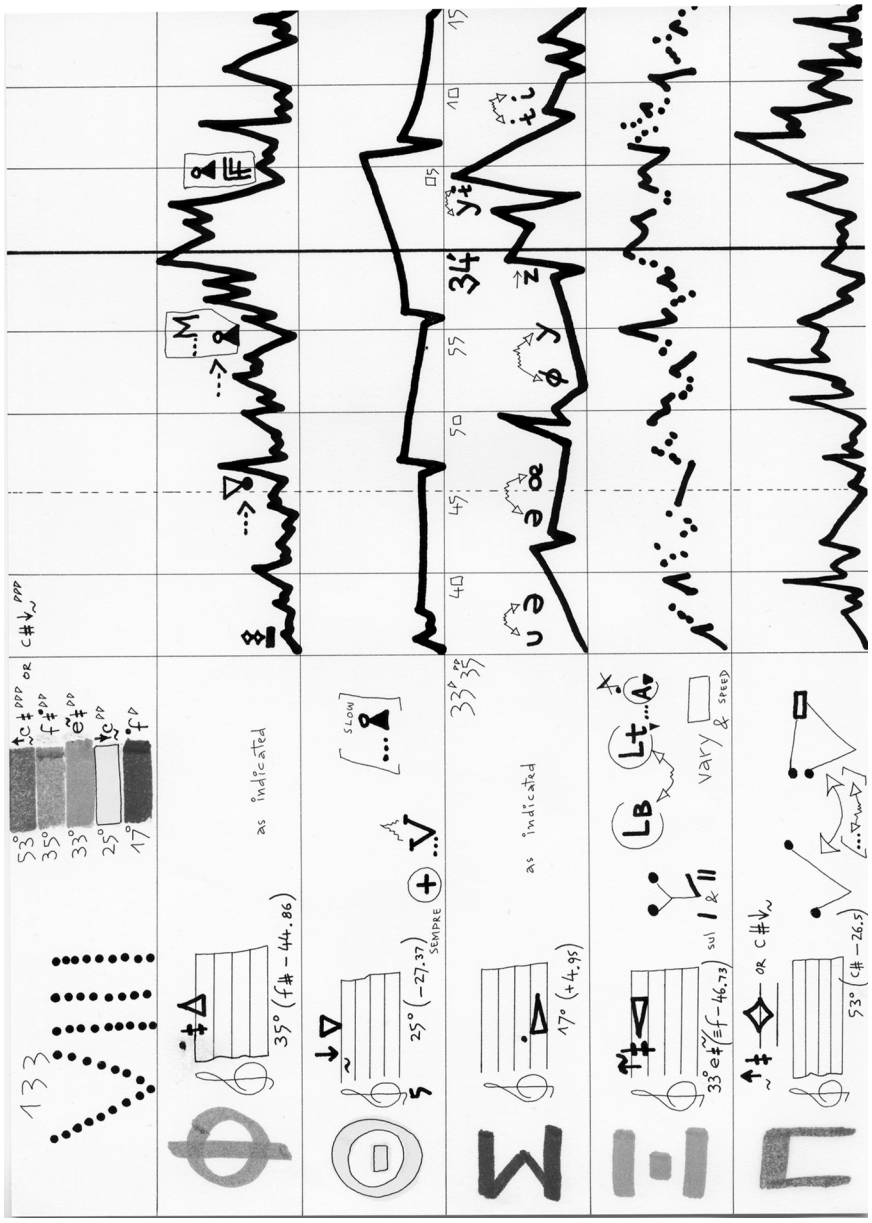

as indicated
35° (f♯ − 44.86)
25° (−27.37)
SEMPRE
SLOW
as indicated
17° (+4.95)
33° e♯(f♯ − 46.73)
sul I & II
vary & speed
53° (C♯ − 26.5)
OR C♯

FIGURE 7a.

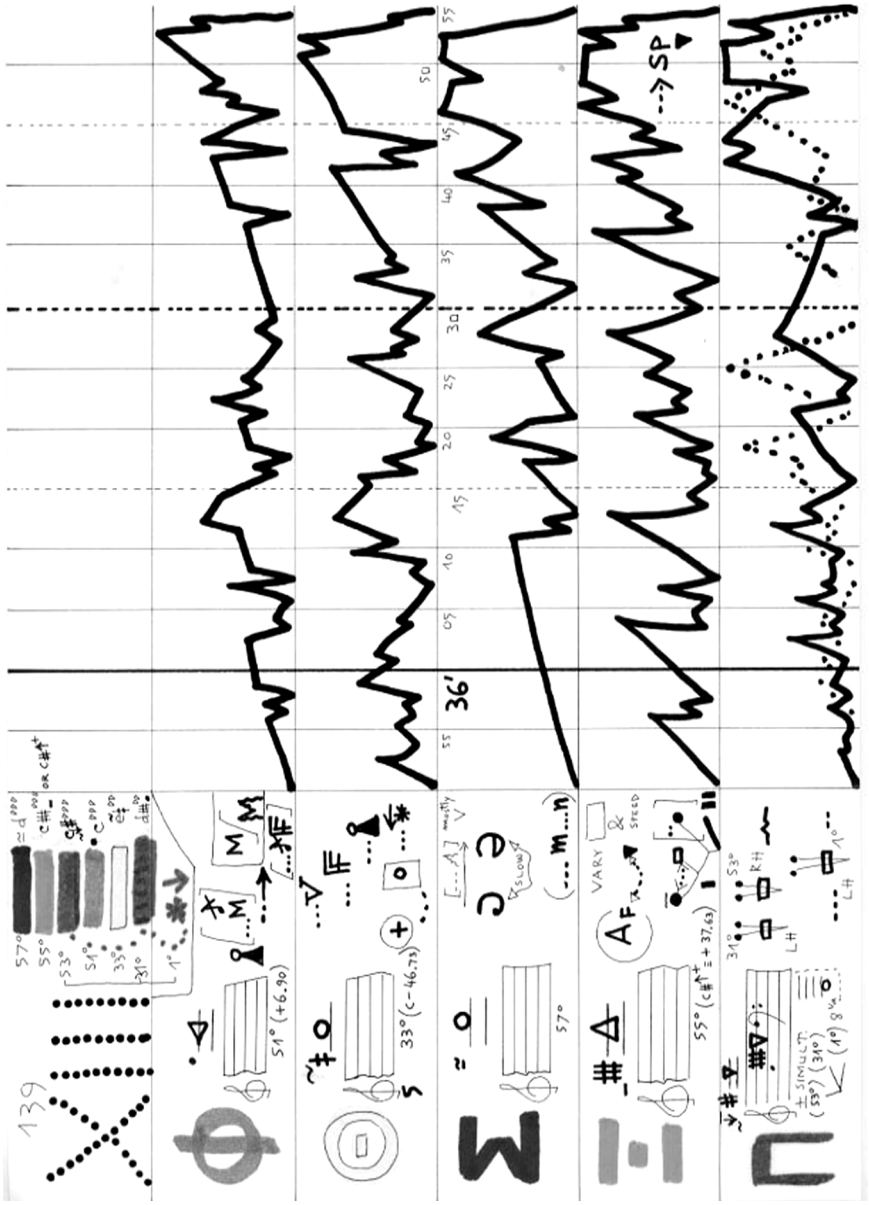


FIGURE 7b.

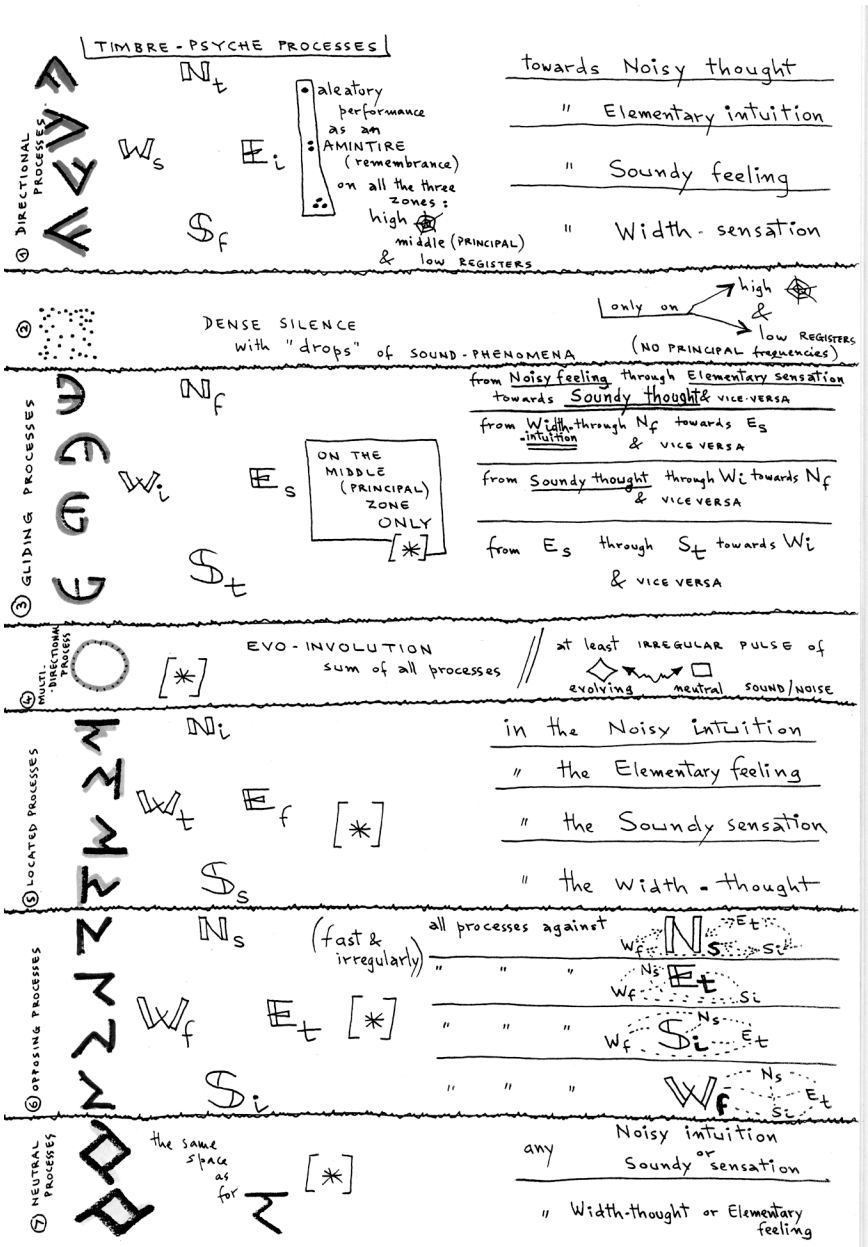

TIMBRE - PSYCHE PROCESSES
① DIRECTIONAL PROCESSES
towards Noisy thought
" Elementary intuition
" Soundy feeling
" Width - sensation
aleatory performance as an AMINTIRE (remembrance) on all the three zones: high middle (PRINCIPAL) & low REGISTERS
② DENSE SILENCE with "drops" of SOUND - PHENOMENA
only on high & low REGISTERS (NO PRINCIPAL frequencies)
③ GLIDING PROCESSES
from Noisy feeling through Elementary sensation towards Soundy thought & VICE-VERSA
from Width-intuition through Nf towards Es & VICE VERSA
from Soundy thought through Wi towards Nf & VICE VERSA
from Es through St towards Wi & VICE VERSA
ON THE MIDDLE (PRINCIPAL) ZONE ONLY
④ MULTI DIRECTIONAL PROCESS
EVO - INVOLUTION sum of all processes
at least IRREGULAR PULSE of evolving neutral SOUND/NOISE
⑤ LOCATED PROCESSES
in the Noisy intuition
" the Elementary feeling
" the Soundy sensation
" the Width - thought
⑥ OPPOSING PROCESSES
(fast & irregularly)
all processes against
⑦ NEUTRAL PROCESSES
the same space as for
any Noisy intuition or Soundy sensation
" Width-thought or Elementary feeling

FIGURE 8.

Compact Spectrum of Totally Unique Functions

"infinite to be cannot be infinite, infinite anti-be could be infinite": 4th String Quartet, op. 33 (1976–1987):

The spectral scordatura of the 128 open strings of the imaginary "viola da gamba" built around the audience by eight quartets, the ninth being placed in the center of the space:

One hundred twenty-eight unique functions of pitch chosen within the harmonics 36 to 641 of a C (1 Hz), cover a range of over four octaves, from D_{-1} to e^2. The "geology" of these functions consists of various densities of pitch, the steps in Hz using different powers of the number 2: 4, 2, 8, and 16 (from low to high register) in order to respect the historic tuning, the tradition of those strings.

By contrast, the central ninth quartet modulates within 27 spectra. It uses ρ, μ, and δ micromusic, that is, ring modulation, multiplication of multiples, and dilation of formants, respectively, the music of "preferential" and "self-generative" functions. Each micromusic is tuned rigorously according to its duration; for example, a music of 13″ uses a spectrum of D 3/4 $tone^+$ sharp (or E 40 cents lower, approximately): this is historically the first scientifically strict interdependence between *time* and *pitch.* Again, in the correlation between time and pitch, brain and sound are two aspects of the same unique reality (cf. part 2, ring spectra) (FIG. 9, spectral scordatura of the 128 open strings in op. 33).

Many other scores use this type of scordatura based on compact spectra of totally unique functions, some as specific situations:

In *Forefeeling Remembrances,* op. 64 (1985), 14 identical voices pulsate the following 14 functions proportionally to their spectral role: 6, 7, 8, 9, 10, 11, 13, 15, 17, 19, 21, 23, 25, and 27.

In *Sensual Sky,* op. 62 (1985), an explicit spectrum is figurated by nine instruments—alto flute, clarinet, alto saxophone, trombone, sound icon, violin, viola, cello, and double bass—while, as background, two contrabass flutes project various implicit spectra on more or less unstable fundamentals via overblowing sound production.

Subconscious Sound Trajectory Inside a Compact Spectrum

Do Emerge Ultimate Silence, op. 30 (1974–1984): A 34-pitch spectral chain describes a 28-minute unique "cantus firmus" of a deeply Buddhist time: a *melopée* (chant) of uphill-downhill profile where each of the 34 spectral sounds appears only once in one of the two "sides" of this melodic mountain. This very slow, mountain-shaped "cantus firmus" is often accompanied by emanations of parts or the whole of the 34 pitch functions. The whole evolves on six concentric groups of children's voices supported by bowed monochords in just tuning: harmonics 11 to 44 of a low D of 18 Hz (g monesis $_0$ - g $monesis^2$). The children sing 34 different pitches within an ambit of two octaves, with steps becoming progressively smaller towards the high register, from the "neutral second" g monesis $_0$ – a $_0$ to an interval smaller than a quartertone, g^{+2} – g $monesis^2$ (monesis = half-sharp).

Do Emerge Ultimate Silence can be realized with 34 soloists or even with 340 voices, that is, 34 groups of 10 voices each, for example, in the Pantheon in Rome.

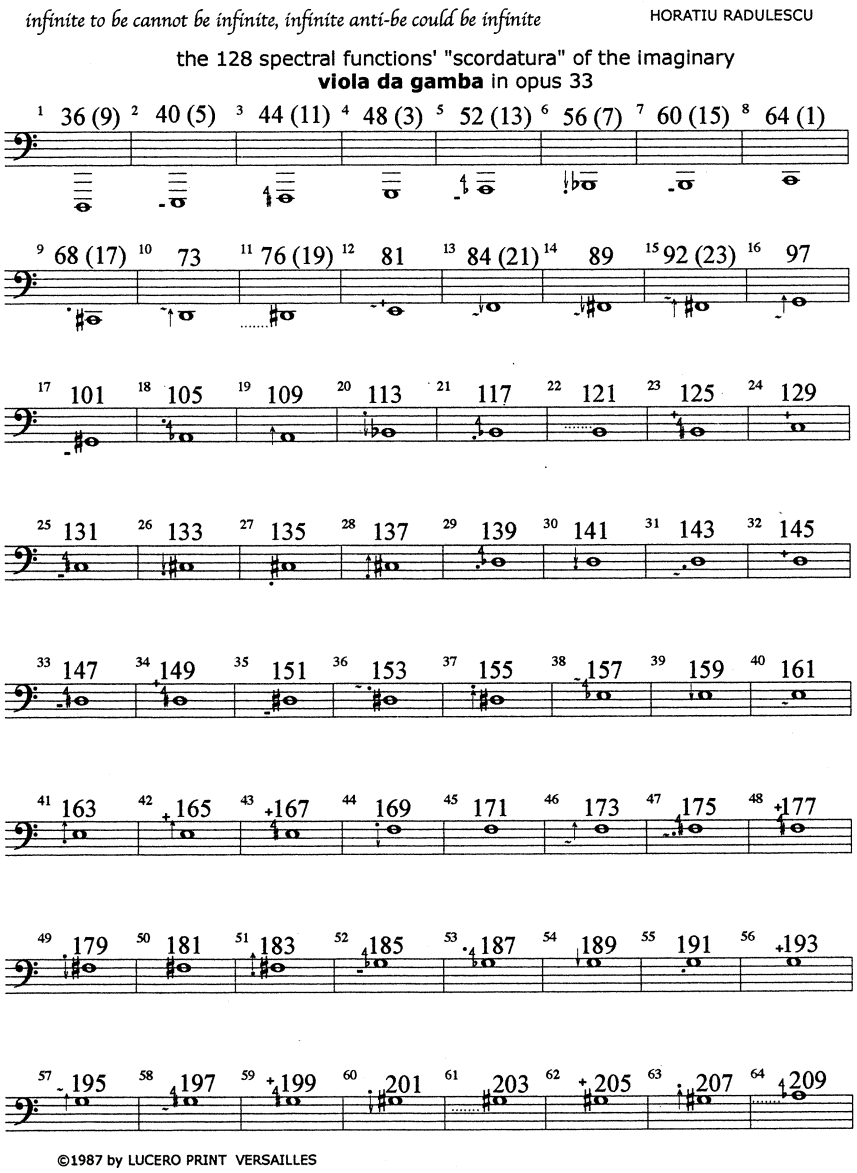

infinite to be cannot be infinite, infinite anti-be could be infinite
HORATIU RADULESCU
the 128 spectral functions' "scordatura" of the imaginary
viola da gamba in opus 33
1 36 (9) 2 40 (5) 3 44 (11) 4 48 (3) 5 52 (13) 6 56 (7) 7 60 (15) 8 64 (1)
9 68 (17) 10 73 11 76 (19) 12 81 13 84 (21) 14 89 15 92 (23) 16 97
17 101 18 105 19 109 20 113 21 117 22 121 23 125 24 129
25 131 26 133 27 135 28 137 29 139 30 141 31 143 32 145
33 147 34 149 35 151 36 153 37 155 38 157 39 159 40 161
41 163 42 165 43 167 44 169 45 171 46 173 47 175 48 177
49 179 50 181 51 183 52 185 53 187 54 189 55 191 56 193
57 195 58 197 59 199 60 201 61 203 62 205 63 207 64 209
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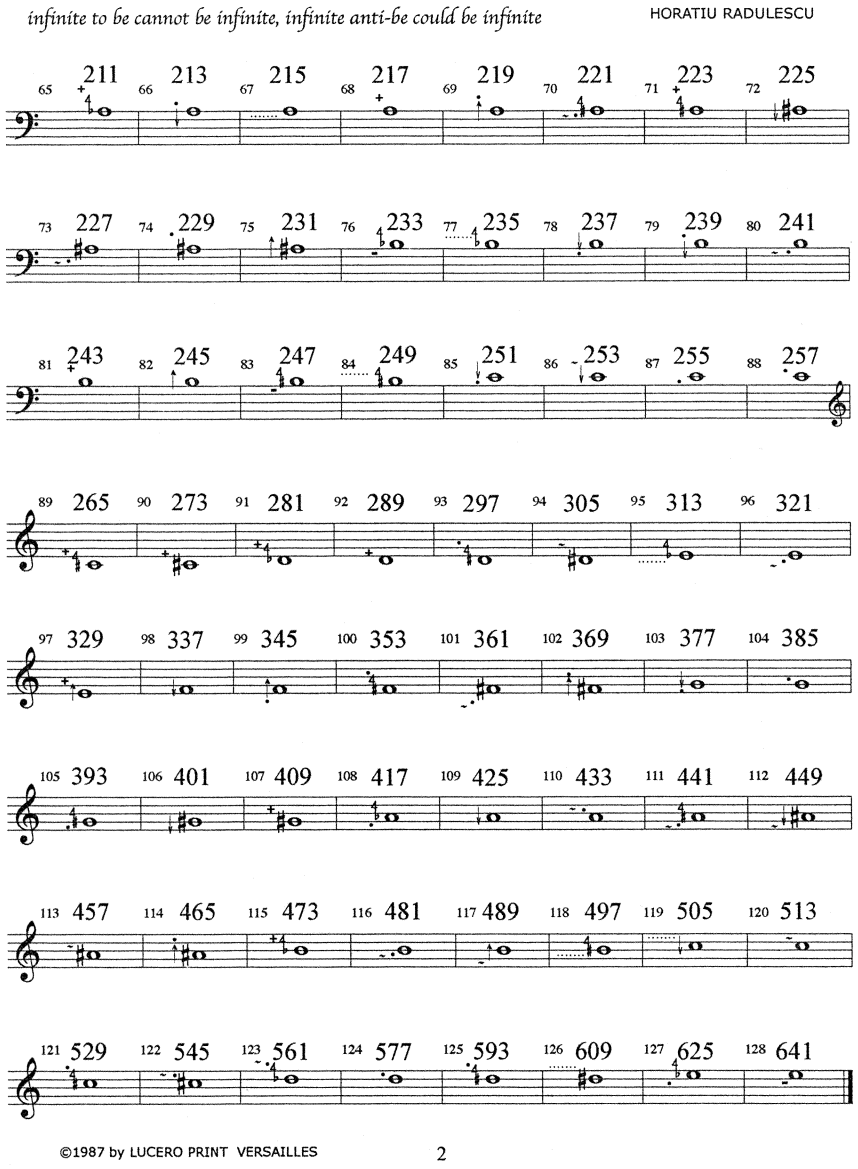
FIGURE 9a.


infinite to be cannot be infinite, infinite anti-be could be infinite
HORATIU RADULESCU
65 211 66 213 67 215 68 217 69 219 70 221 71 223 72 225
73 227 74 229 75 231 76 233 77 235 78 237 79 239 80 241
81 243 82 245 83 247 84 249 85 251 86 253 87 255 88 257
89 265 90 273 91 281 92 289 93 297 94 305 95 313 96 321
97 329 98 337 99 345 100 353 101 361 102 369 103 377 104 385
105 393 106 401 107 409 108 417 109 425 110 433 111 441 112 449
113 457 114 465 115 473 116 481 117 489 118 497 119 505 120 513
121 529 122 545 123 561 124 577 125 593 126 609 127 625 128 641
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2

FIGURE 9b.

The psychoacoustic tension is intense throughout the concert hall or church, the 34 points being symmetrically distributed thoughout the audience: the result is a circular movement of sound or the eruption of chords, with different pitches or in unison, all voices contributing the private sound of their monochord or imitating other voices in unison, and each voice singing, at least once, each of the 34 harmonics. Sometimes the movements of sound on different concentric groups can revolve contrariwise and at a very different speed and with varying densities of the voices. Each group of voices uses a unique selection of functions without any repetition inside the

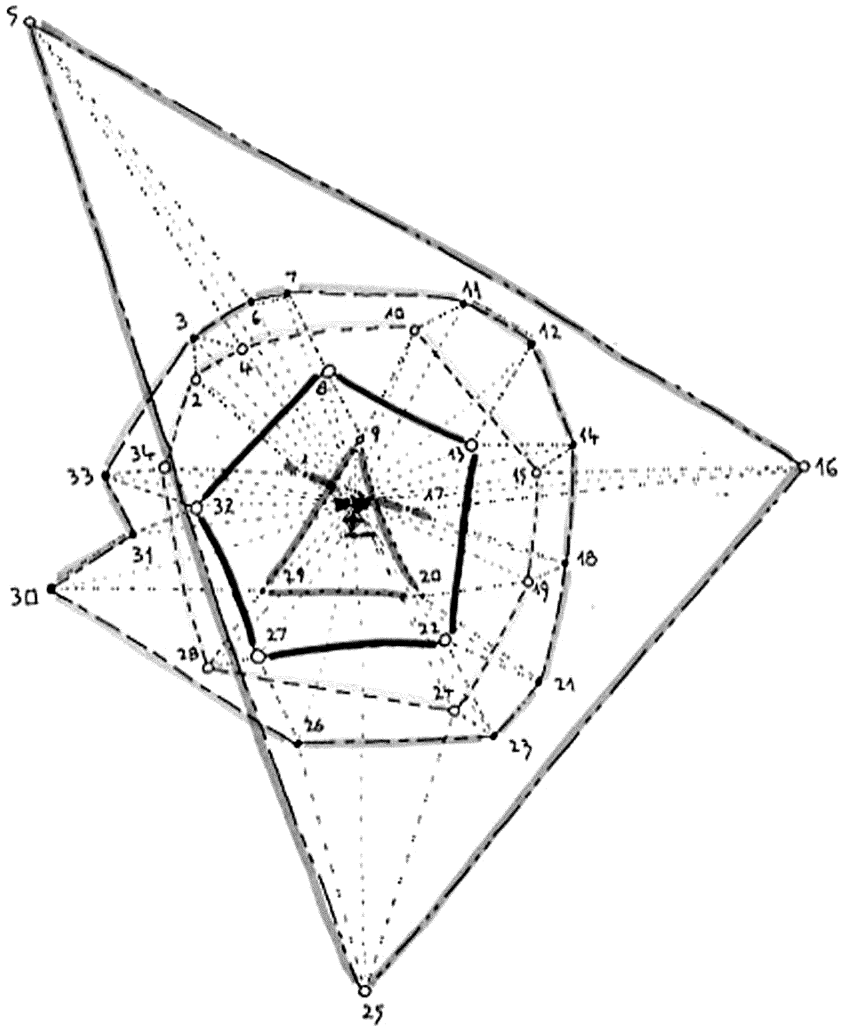


FIGURE 10.

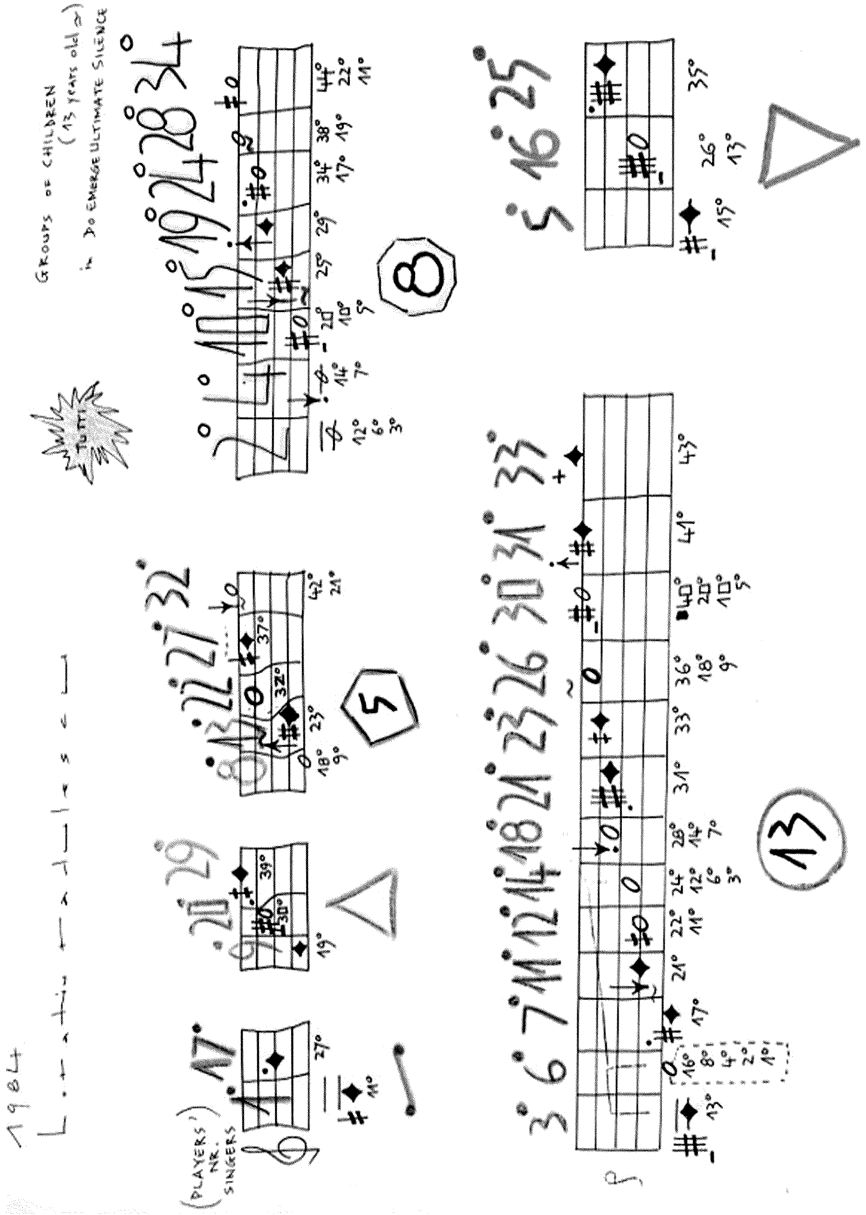

1984
(PLAYERS' NR. SINGERS
GROUPS OF CHILDREN
(13 years old)
to Do EMERGE ULTIMATE SILENCE
TUTTI
5
8
13

FIGURE 11.

same group. There are 2, 3, 5, 8, 13, and 3 voices per group, respectively. The seventh group is the "zigzag star" of tutti (all 34 voices) (FIGS. 10 and 11).

Double and Complementary "Bridges" of Compact Spectra

Incandescent Serene, op. 35 (1982): Twelve quartets, each consisting of one contrabass flute, one viola, one horn, and one double bass, figurate filters of aural information ("plages de l'audible") of a horizontal "sand clock" and of rhombus shapes that integrate a chain of 137 micromusic "mobiles." The upper "bridge" is built on a virtual scordatura from harmonic 12 (G_0) to 83 (e monesis[1]) and is played by flutes, violas (specially retuned according to elements of a C spectrum), and horns. The contrary lower "bridge," built on a spectral scordatura from harmonic 16 to 95 (same order numbers being also the actual Hz), is played by the double basses. The unique frequency plateaus of the open strings of the double basses correspond per string to harmonics 16 to 27 (string IV); 28, 29, 30, 31, 33… 45, 47 (string III); 49, 51… 69, 71 (string II); 73, 75…93, 95 (string I).

Compact Spectra of Unique Functions (No Repetition at Just Octaves), Each Revolving at a Different Speed

The family of compositions op. 42α, *Outer Time,* and op. 42β, *Inner Time* (1980–2003): In *Outer Time,* for 42 Thai gongs spectrally tuned (harmonic 6 to 83 or 11 to 83), the virtual spectral scordatura uses harmonics 6 to 11 or 11 to 21 as a compact zone and then only odd harmonics up to the 83rd in order to obtain a row of 42 unique spectral functions, as unique as the 12 pitches of a Webern serial row.

Four layers of time/speed are simultaneously perceived:

MMT – Macro Macro Time, e.g., 62′ 13″ (whole macroform)

mMT – micro Macro Time, e.g., 5″ up to 55″ (the 137 mobiles)

MmT – Macro micro Time, e.g., one attack per ± 1″ (the 81 "rhythm characters")

mmT – micro micro Time, e.g., aural information of about 1/333 of a second (2–3 ms).

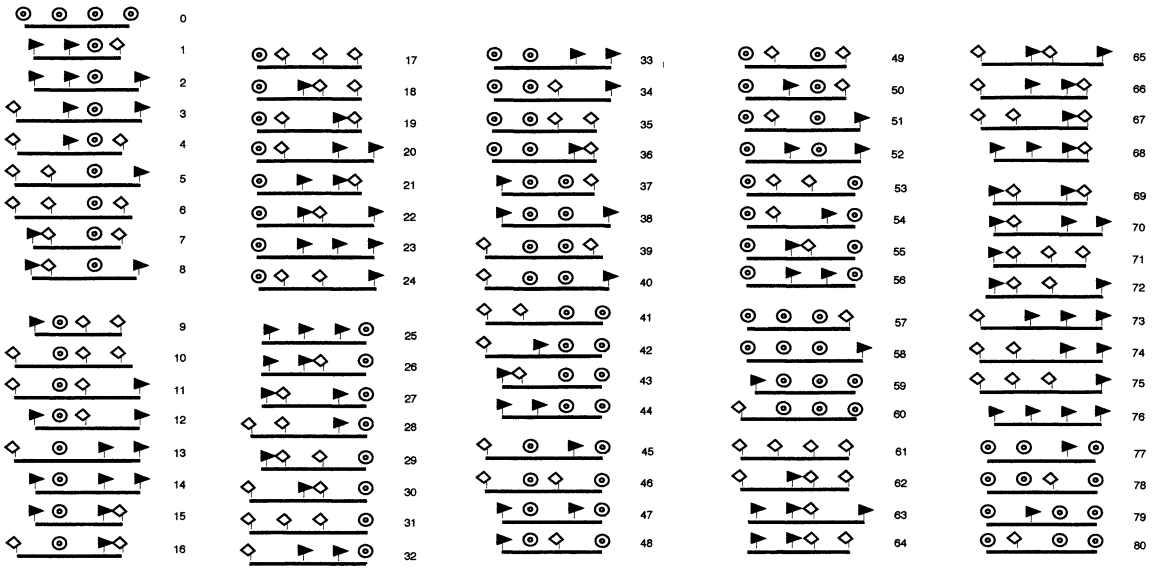
On the 42 spectral "orbits," the pitch functions revolve at a speed ranging from 11 circles for the lowest function to 83 circles for the highest one, over a total duration of 62′13″ (FIG. 12, the 81 rhythm characters [microagogic rhythm] used in various scores such as "practicing eternity," String Quartet no. 6, op. 91 (1992); FIG. 13, one of the 56 pages of *Outer Time*).

Reverse and Compact Spectra

[ɩ] inverse spectrum and [ε] explicit/compact spectrum (e.g., the scordatura of the 11 strings in *Unde Incotro* [′un de în ko ′tro] (and *Where Beyond*), op. 55 (a and b) (1984, 1992): From left to right: double bass, two celli, two violas, and six violins - a direct display of sources in a semicircle on stage (plus alto flute in the b version, *Where Beyond*): left/low – right/high, according to the specialization of our stereo hearing. The lowest functions are the secondary and tertiary ones, unique theoretical harmonics 6 to 47 as the scordatura of strings, while the highest are the primary ones, harmonics 1, 2, and 3, each on a great number of strings (FIG. 14, scordatura of unique strings in *Unde Incotro*).

HORATIU RADULESCU "practicing eternity" VI th STRING QUARTET opus 91

the 81 rhythmic characters



" use your own light and return to the source of light, this is called practicing eternity "
LAO-TZU : *Tao Tè Ching*

FIGURE 12.

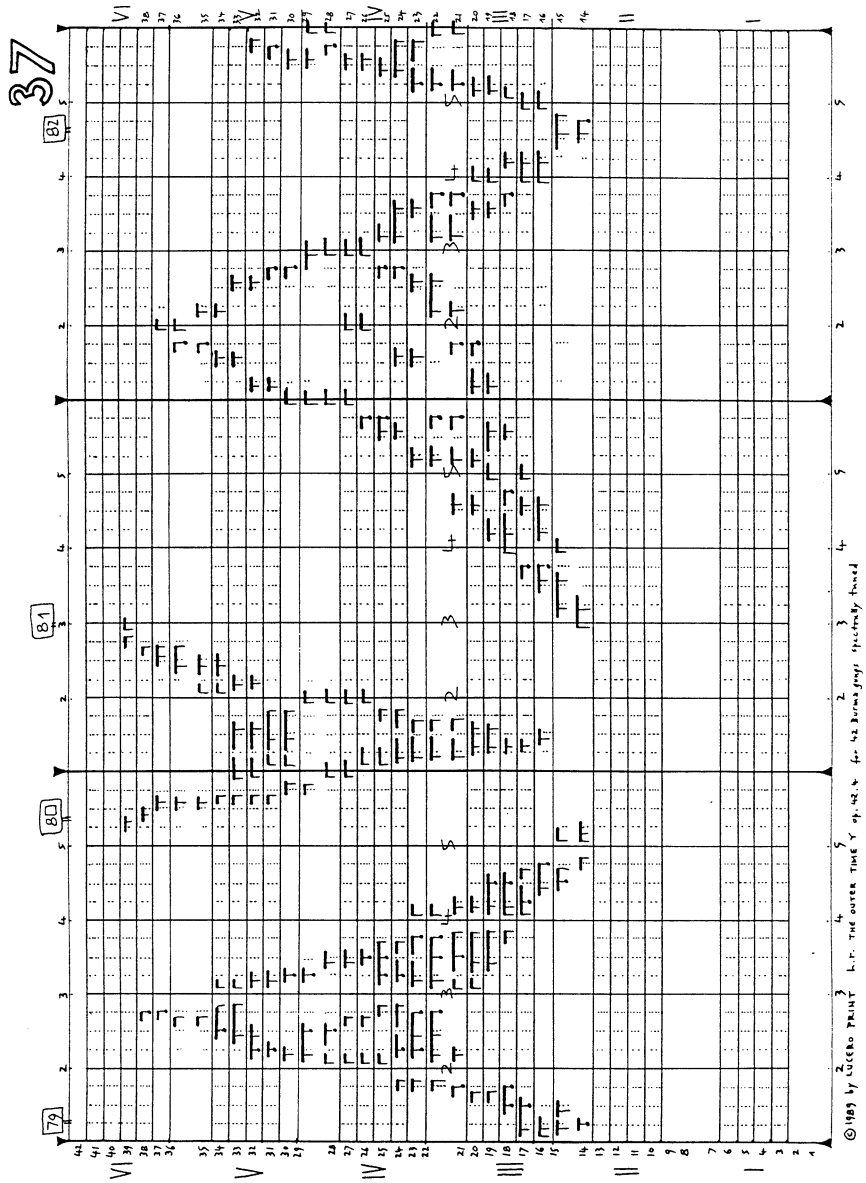


FIGURE 13.

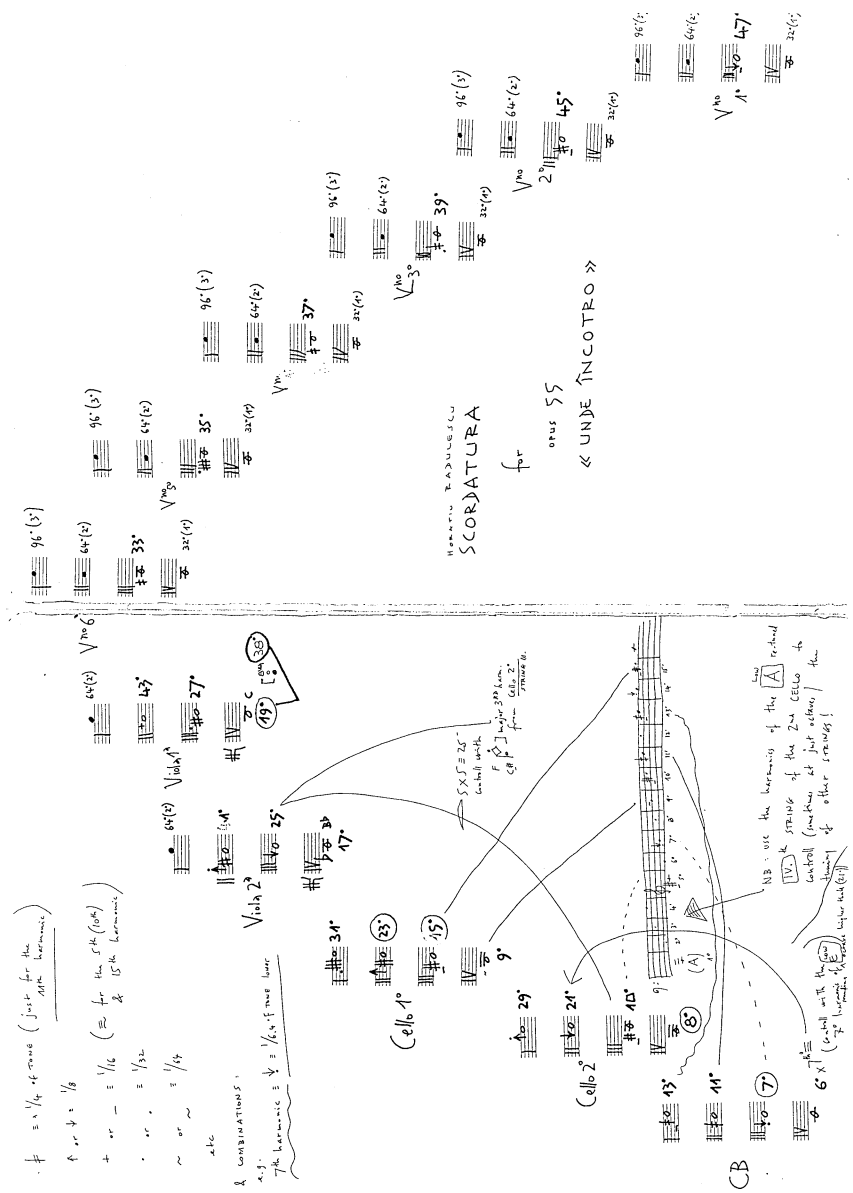


FIGURE 14.

RING SPECTRA: PREFERENTIAL PHENOMENOLOGY USING SPECTRAL FILTERING ACCORDING TO RINGS OF RESONANCE

Proto Ring Spectra

The interference of frequency multiples (spectral components) produces additional and differential sounds (sum and difference tones), the latter also being multiples of the same fundamental, that is, belonging to the same spectrum. Such a ring modulation of functions is perceived by our brain in a condition of high intensity (e.g., we hear four pitches while playing only two). We can emancipate these virtual functions, even at low dynamics, and make them, for musical reasons, into "real" pitches. Thus, we arrive at completely unfamiliar simultaneous pitch functions (formants), resulting from specific spectral self-generative processes.

For example, primal functions 16 and 21 produce functions 5 and 37. This type of ring function is encountered in very early works such as *Omaggio a Domenico Scarlatti,* op. 2 (1967), for piano or harpsichord, approximated by tempered elements: e_0 c^2 f^2 e $flat^3$. In particular, the lower part of the formant contradicts the rules of classic harmony and counterpoint: its simultaneity of major third (harmonic 5), tonic (harmonic 16), and perfect fourth (harmonic 21) is not allowed and is considered dissonant in the history of music, but now becomes an element of a self-generative chain, a genealogic tree of frequencies, for both our brain and our musical language, most healthy and "consonant." This psychoacoustic triad is now one of my musical signatures.

Another proto ring spectrum approximated by tempered elements is that of the end of *Taaroa,* op. 7 (1968–1969), for orchestra, humanized by the singing of all of the players, where the theoretical harmonic 15 (leading tone or "sensible") and 17 (Phrygian second or Neapolitan minor second) produce in sum 32 (tonic), which easily is allowed to have its perfect fifth (dominant), this resulting also from the further ring modulation as additional 47 (32+15) and 49 (32+175), giving in the upper register the 96 (3) [47+49], a just octave of the dominant. This formant 15-17 – 32-48 is a chord that Sergiu Celibidache appreciated and loved: acoustically and spiritually "our imperfect step," a slightly wider major second as in some Hindu and Byzantine music, towards—in the high—"the Eternal," the perfect fifth of Pythagoras, Guillaume de Machaut, and Josquin Des Prez.

Proto ring modulation of spectral functions produces a "Brancusi infinite column," a modal chain based on only two intervals (harmonics 6-7 and 13-16, in a condensed register [$m3^{rd}$ – $p5^{th}$, - $m3^{rd}$ – $p5^{th}$, and so on]). This can be further transposed via pivot functions until the whole chromatic set of 12 different pitches is reached. I used this approach in *Madrigal,* op. 3 for children's voices and orchestra (1967), *Being and non-being create each other,* Piano Sonata no. 2, op. 82 (1991), the Piano Concerto *The Quest,* op. 90 (1996), and other works.

Another proto ring spectral function produces a similar but different type of Brancusi infinite column, a modal chain based also on only two intervals (harmonics 7-8 and 12-13, in a condensed register [$M2^{nd}$ – $p5^{th}$, - $M2^{nd}$ – $p5^{th}$, and so on]). Further transposition via pivot functions gives the defective chromatic set of eight different pitches. *Agnus Dei,* op. 84 (1991), for two violas is entirely built on those two columns. Related also is the fourth movement of the 3^{rd} Piano Sonata, op. 86, where the "Dance of the Eternal" is based on the first column (of 12 different pitches) and only

the conclusion, surprisingly, brings the acoustic freshness of the second column (of eight different pitches).

Advanced Ring (ρ), Dilation (δ), and Multiplication (μ) Spectra

As we saw in the section on the 128 open strings of the imaginary viola da gamba built by the eight surrounding string quartets of op 33, the 128 unique functions of pitch permit these three types of spectral life to materialize. The ninth quartet in the center is based mostly on ρ and only exceptionally on δ and μ as well as very intense and "multiple-stringed" unisons. As an example of how music ρ can create a historically new language, we look at the very first micromusic where *three unique and different types of f are presented against C*: harmonic 21 (f^3 1/7 tone lower), 22 (f^3 monesis) as generators, harmonic 43 (f^4 1/17 tone higher) as additional, and 1 (the fundamental C_0) as differential.

We know that in the recent history of serial, modal, and polytonal music only two different types of a same step of the mode were used more or less simultaneously (Webern, Bartók, Stravinsky, Enescu, Hindemith, Stockhausen, Berio, Boulez, Nono, *et al.*), for example, b natural $_0$ (c flat ^{1}) – f ^{1} – b flat ^{1} (Webern), e $_0$ – c ^{1} – e flat ^{1} (Enescu).

Music δ operates a special filtering on a spectrum. A chord of several harmonics, for example, 3, 4, 7, and 11 (vicinity +1, +3, +4), is imagined in other formants of the same spectrum, keeping constant the vicinity proportions around an axis [α] or starting from the bottom [β] or from the top [γ]. If we consider the inner axis 4 – 8 – 16 – 32, then the different formants, ranged vertically, describe the following chain of chords. To feel the dilation/contraction of the same formant/chord keeping the vicinity proportions stable, we are obliged to make all of these chords dance around the axis with their different modal content as represented by colors: red (the most spread chord) green, blue, and finally (the most condensed one) violet. To actually feel the process, the axis was kept on place, stable, as if the fundamental were jumping on different octaves to obtain all of those harmonics with different order numbers. This means that we perform just the violet functions, that is, we are on very high formant strata operating various filtering on the same spectrum region. In any case, the actual spectral functions are the left colored numbers, whereas the division by two is no longer possible at the given rank of functions. We notice that in this example the ambit of nearly two octaves is progressively contracted to an augmented octave, then further to a slightly augmented perfect fifth, and finally to a major third.

The rich content in various microtonal pitches of the spectrally tuned 128 open strings enables music δ to be produced. The players of the central quartet realize a chorale of dancing formants of δ music too, but they are obliged to use special microtonal functions produced by unusual fingerings, because their instruments are tuned normally, using an a^1 of 432 Hz.

The very complex δ music events of this imaginary 128-string "viola da gamba," sometimes combined simultaneously with ρ or being crossed by τ music events, were computed in Paris by Vincent Bourgue using 16 dimension-calculus and probabilistic approach with chance variables.

Example of music δ with inner axis 4 – 8 – 16 – 32; the resultant formants/chords are ranked among the differently colored columns.

NB! We keep constant the vicinity proportions (vicinity +1, +3, +4):

[a] around an inner axis (see previous page) or

11	14	20	32
7	10	16	28
4	7	13	26

[b] starting from a stable bottom 3 - 6 - 12 - 24
or [g] from a stable top 11 - 22 - 44 - 88

7	18	40	84
4	15	37	81
3	14	36	80

AdvancedExplicit/Compact [ϵ], Ring [ρ], and Inverse Spectra [ι]

Seven spectra in *Iubiri* (Amours), op. 43 (1981), consist of 343 unique micro-music events that integrate a registral shape of an enormous horizontal "sand clock" of 46'–from a seven-octave range to a focus on a central d' and then a faster widening back to seven octaves, but giving a constant feeling of ascension because the fundamentals of the seven modulating spectra-regions are the first seven different theoretical harmonics of the primal spectrum: 1, 3, 5, 7, 9, 11, and 13. These functions are reinforced exactly where their original ascending places are located within the primal spectrum (FIG. 15, registral evolution of the *Iubiri* macroform; FIG. 16: (a) fragment of score; (b) fragment of a flute part).

A related concept is that on which *Awakening Infinity,* op. 53 (1983), is based, where 25 players are placed on stage in a circle, reversed and augmented in the auditorium via slight amplification. A simultaneous double complementary stereophony is perceived, for example, a diagonal on and from the stage heard as SW-NE is heard at the same time from and in the concert hall spatially augmented and reflected as NW-SE. These two circles of stereophony build a figure of 8: two superimposed circles constituting the subconscious upright symbol of an "awoken infinity."

Implicit [ι–ρ] Ring Modulations Through Sums (Σ) of High Harmonics' Biphonies (Harmonics 7 to 20) Producing at High Intensity Various Differential Sounds; Explicit [ε–ρ] Ring Modulations as Arpeggios (A) of Chords Built on Spectral Components of Virtually Very Low Fundamentals

Das Andere, op. 49, for viola or cello (1984) (NB: performed by the cellist Catherine Marie Tunnell in Venice at the Neuroscience and Music Congress 2002) and *You - tree kalotrope,* op. 57 (1985), for tuba and double bass with background of eight shakuhachi (those of *Starriness,* op. 52, based on the random spectra of "whistle sounds" of the eight flutes) (FIG. 17 (a and b): macroform with S and A patterns in *Das Andere;* FIG. 17(c), fragment of page 13 of the score).

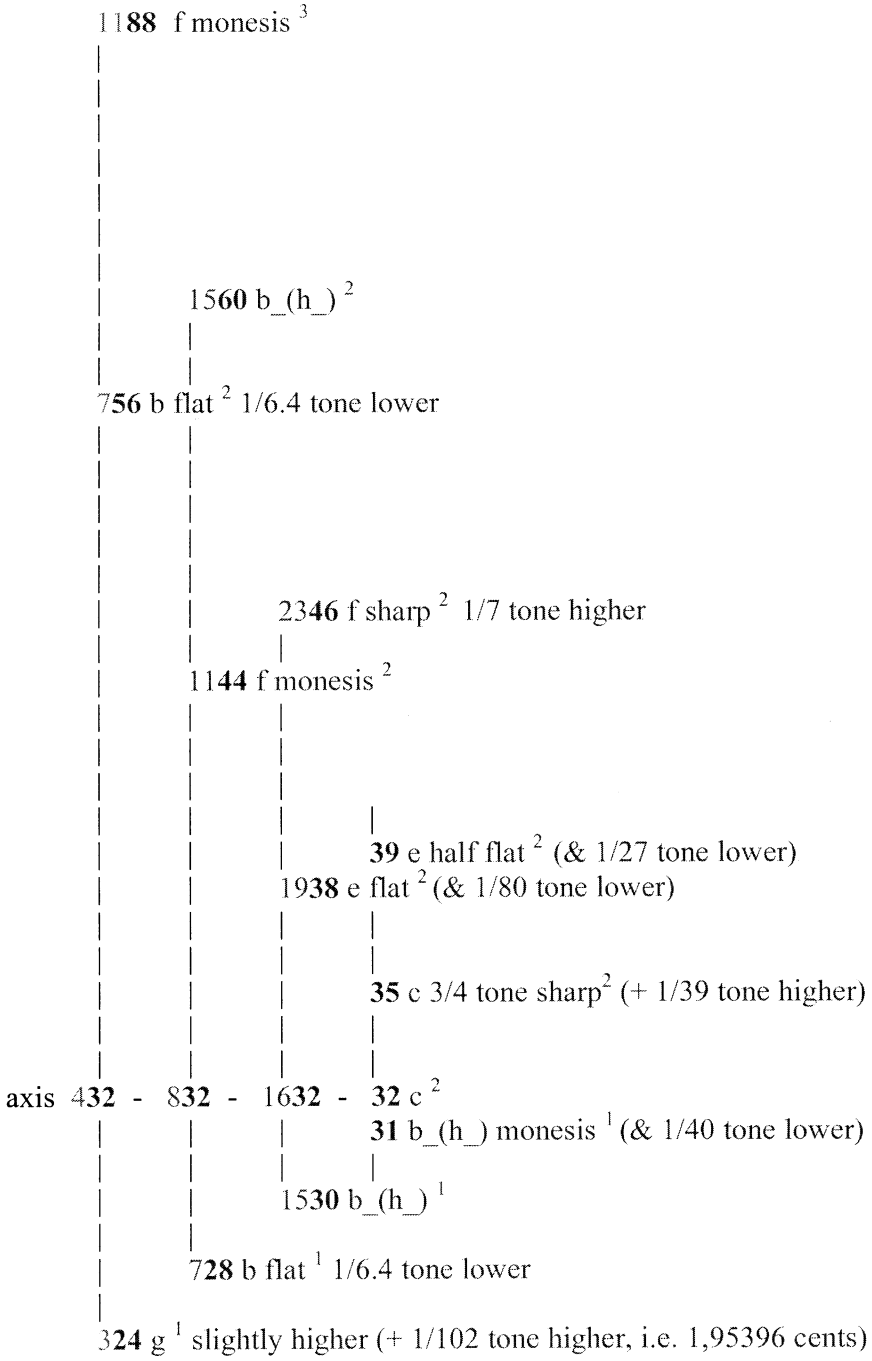
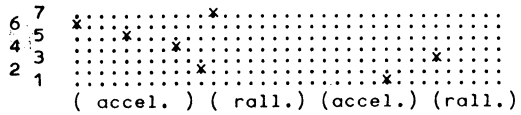
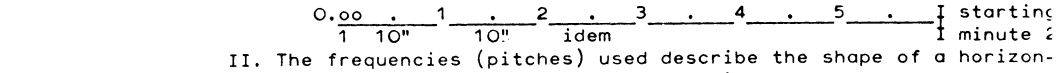

1188 f monesis 3
1560 b_(h_) 2
756 b flat 2 1/6.4 tone lower
2346 f sharp 2 1/7 tone higher
1144 f monesis 2
39 e half flat 2 (& 1/27 tone lower)
1938 e flat 2 (& 1/80 tone lower)
35 c 3/4 tone sharp2 (+ 1/39 tone higher)
axis 432 - 832 - 1632 - 32 c 2
31 b_(h_) monesis 1 (& 1/40 tone lower)
1530 b_(h_) 1
728 b flat 1 1/6.4 tone lower
324 g 1 slightly higher (+ 1/102 tone higher, i.e. 1,95396 cents)

FIGURE 15a.

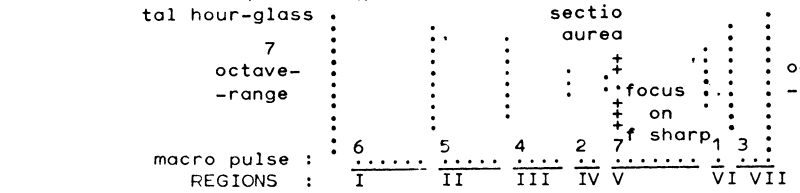
I. There are 343 orchestration-impulses fighting against and within a periodicity which itself has the time proportion : 6 5 4 2 7 1 3 . In other words the 7 regions of the work each contain 7 bridges (each of which itself contains 7 orchestration-impulses The first 49 orchestration-impulses happen every 6 beats (where 1cm=2sec.). In the second region, the orchestration-impulses occur every 5 beats, etc...
This macro-pulse of the tempi could be shown :



The strict proportional writing of these tempi uses the unit of 1cm for a light signal pulsating at 2 second-intervals. The device built for this purpose gives colour-light-signals for a mesure of 5 centimeters (lasting 10 seconds) :
RED (left wall) & VIOLET,VIOLET,VIOLET,VIOLET (right wall) as a mesure of $\frac{5}{2}$ where each half note 𝅗𝅥 lasts 1 centimeter and equals ♩ =30 MM.
Therefore the minutes are indicated in the score: 𝅗𝅥, 2𝅗𝅥, etc and for each 10 seconds:



II. The frequencies (pitches) used describe the shape of a horizontal hour-glass



Each region is built on "fundamentals" taken from SPECTRA of different pitches:
Ist region of C ; IInd of G ; IIIrd of E ; IVth of B♭ flat ; Vth of D ; VIth of F♯ ; VIIth of G♯ .
The fundamental of each region is itself the NEXT (ODD) NEW HARMONIC of the ORIGIN-SPECTRUM of C.
It should be noted that sometimes the pitches were deduced from very high layers of those SPECTRA, which contain more and more compressed (minute) micro-tonal divisions of the octave, the logarithmical enrichment per octave increasing according to the row 0, 1, 2, 4, 8, 16, 32, 64,etc..., which is equivalent to the number of new frequency-functions found per octave.

FIGURE 15b.

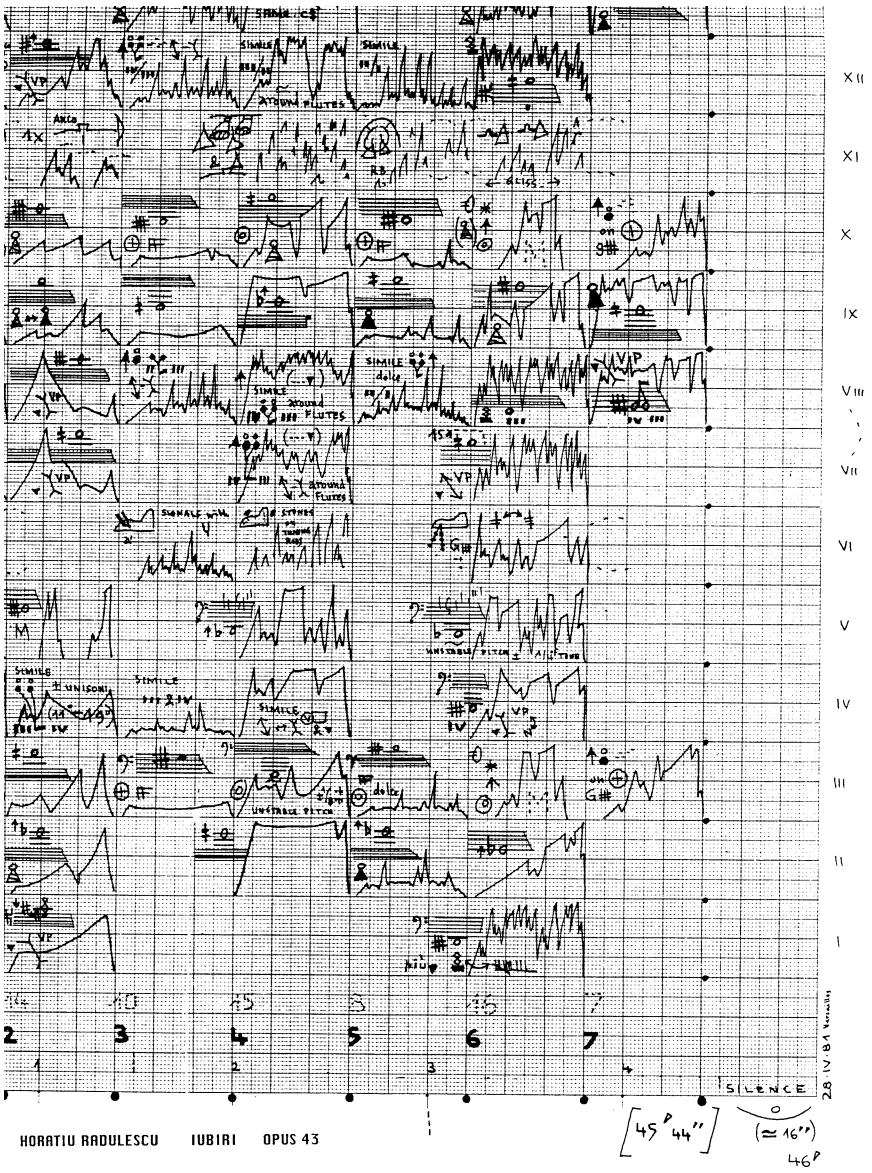

HORATIU RADULESCU IUBIRI OPUS 43
SILENCE
[45" 44"]
(≃ 16")
46"
28 IV 84 Versailles

FIGURE 16a.

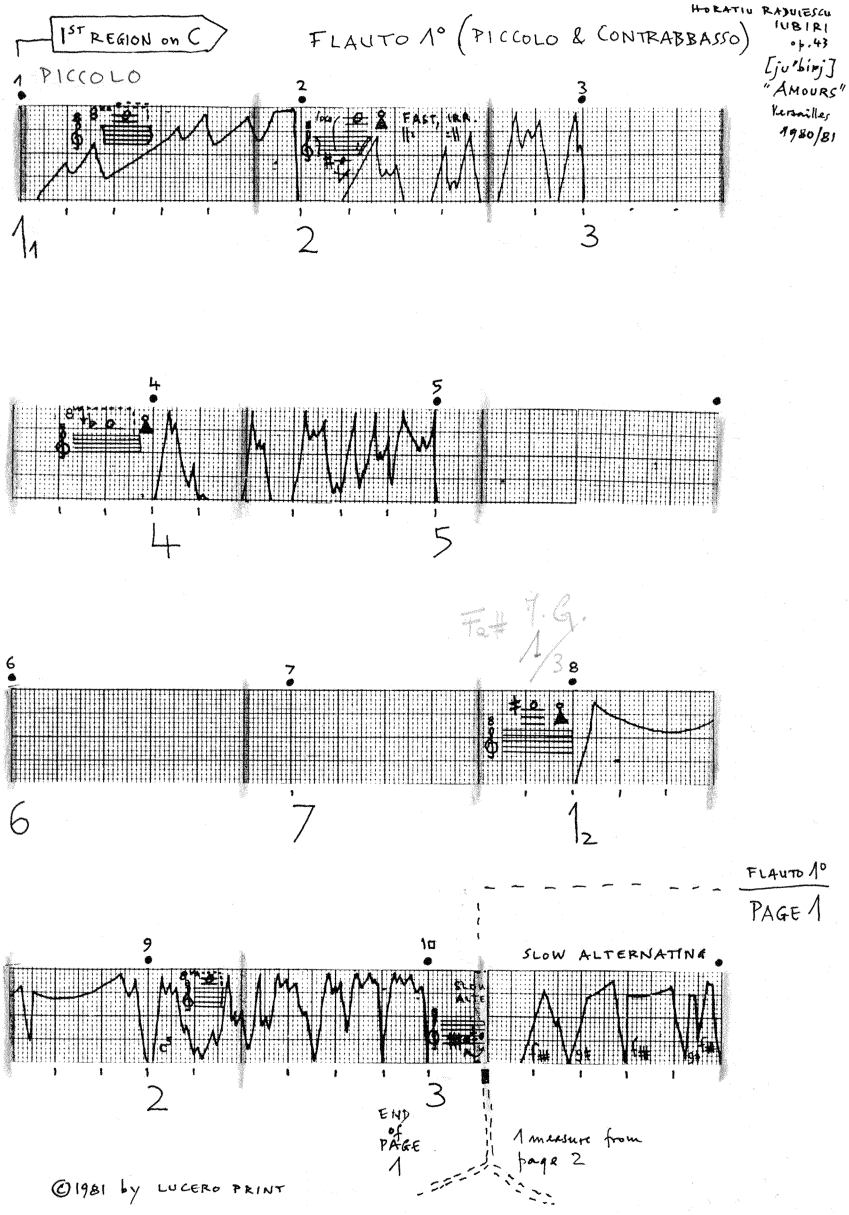

1ST REGION on C
FLAUTO 1° (PICCOLO & CONTRABBASSO)
HORATIU RADULESCU
IUBIRI
op.43
[jubiri]
"AMOURS"
Versailles
1980/81
PICCOLO
FAST, IRR.
FLAUTO 1°
PAGE 1
SLOW ALTERNATING
END of PAGE 1
1 measure from page 2
©1981 by LUCERO PRINT

FIGURE 16b.

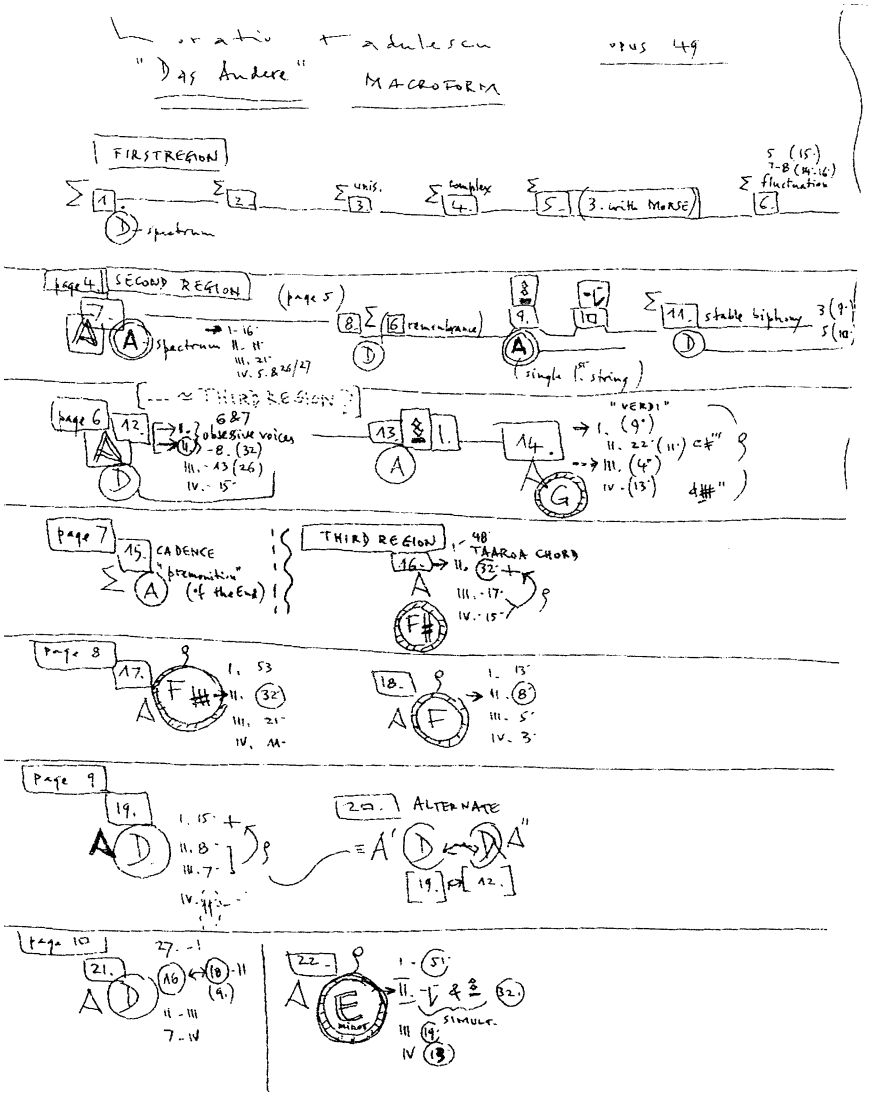

"Das Andere"
MACROFORM
opus 49
FIRSTREGION
SECOND REGION
(page 5)
(page 4)
THIRD REGION
(page 6)
(page 7)
(page 8)
(page 9)
(page 10)
spectrum
remembrance
stable biphony
single (1st) string
obsessive voices
CADENCE
"determinative"
(of the End)
TAARQA CHORD
ALTERNATE
stimulr.

FIGURE 17a.

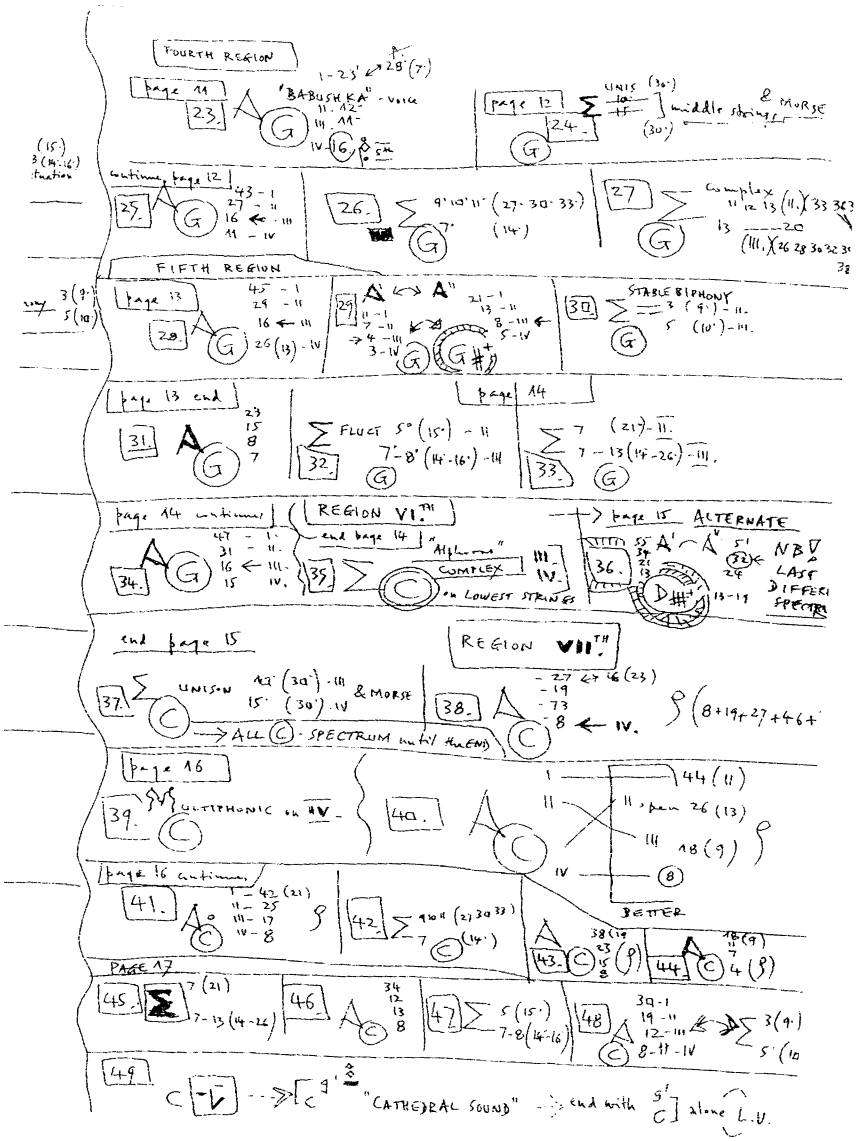

FOURTH REGION
page 11
23.
"BABUSHKA" - voice
page 12
24.
UNIS
& MORSE
middle strings
continue page 12
25.
26.
27
Complex
FIFTH REGION
page 13
28
29.
30.
STABLE BIPHONY
page 13 end
31.
FLUCT
page 14
32.
33.
page 14 continue
REGION VI.TH
end page 14
"Alpha"
COMPLEX
on LOWEST STRINGS
34.
35.
36.
page 15 ALTERNATE
NB
LAST
DIFFERE
SPECTR
end page 15
REGION VII.TH
37.
UNISON
& MORSE
38.
ALL © - SPECTRUM
page 16
39.
ULTIPHONIC on IV -
40.
page 16 continue
41.
42.
BETTER
43.
44.
PAGE 17
45.
46.
47.
48.
49.
"CATHEDRAL SOUND"
end with
alone L.V.

FIGURE 17b

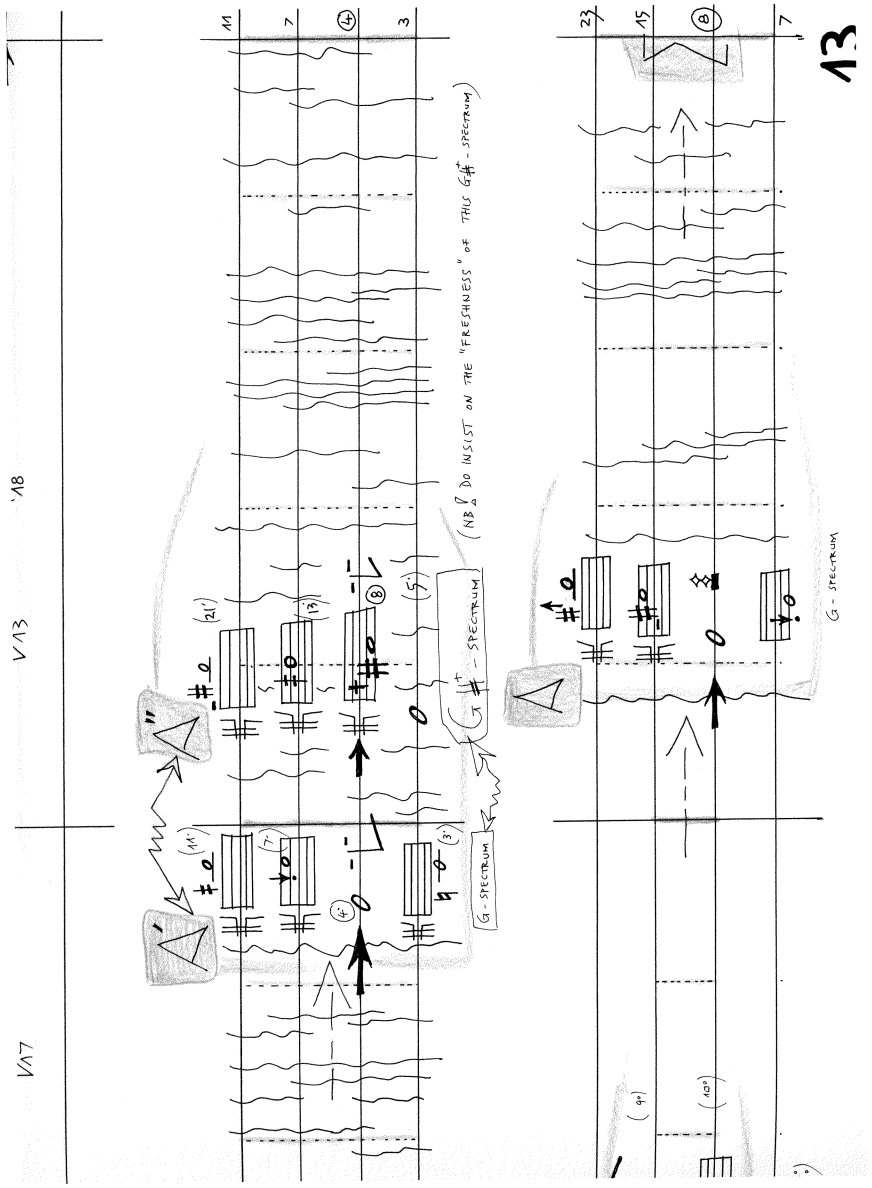

V17
V13
'18
(NB. I DO INSIST ON THE "FRESHNESS" OF THIS G#+ - SPECTRUM)
G#+ - SPECTRUM
G - SPECTRUM
G - SPECTRUM
13

FIGURE 17c.

Explicit [ρ] Ring Formants as Slowest Arpeggio Arches

Sums and differences of harmonics up to the 23rd built on all fundamentals are implemented by the solo trombone in *Trombe d'oro della solarità,* op. 65 (1986). The whole should be realized in a very resonant medium (a Romanesque church, e.g., Speyer Funeral Basilica of the German Emperors, about 1030–1061) with a background music of sound icons performing low random spectra as "thunder"-sound, with rosined thick bow-threads on the lowest strings of concert grand pianos (preferably Imperial Bösendorfers) (FIG. 18, a page of the score, with logarithmic spectral natural intervals).

Erupting [ρ] Ring and [Π] Random Spectra with Increased Spatial Movement

Mirabilia Mundi, op. 70, for 7 large ensembles (1986, ca. 88 players): 12 strings, 17 flutes, organ, 8 trombones, 12 players with gold and silver crotales, 13 very large tam tams, 25 bass voices of monks (moving sound source), is a ritual for the same resonant Speyer Basilica. The resonance of 14 seconds in the Speyer Basilica inspired us to use a special display of the sound sources in concentric circles, as close as possible to the audience, and at "sacred" points, resembling imaginary knots of the total space vibration.

Similarly, the 40 flautists with 72 flutes in *Byzantine Prayer–Requiem for Giacinto Scelsi,* op. 74 (1988), read a score on two different but simultaneous pages: the whole 40-point "star" of flutes and/or the dialogue in between the 8 concentric groups of flutes materialize "Venetian" cori spezzati or various circular sound movement on elements of erupting ring [ρ] and of random spectra [Π].

For the psychoacoustic "volcano" created by the great number of flutes in a highly resonant room, again authentic old sacred spaces are preferred, as in the case of *Do emerge ultimate silence* with the children's choirs; the Rome Pantheon, for example, might be an ideal location for this ritual.

Genuine [ρ] Ring Scordatura and [π] Microrandom Spectra

Solo instruments such as the violin (with the singing voice of the performer) in *Dr. Kai Hong's Diamond Mountain* VI and VII, op. 77 (2001–2002), the double bass in *Azzurro profondo dello sguardo,* op. 78 (2002), the cello or viola in *Lux Animae,* op. 97 (1996), or even the percussion with seven wooden monks' plates in *Eterno,* op. 103 (2002), all with ring spectral scordatura, are all reinforced by the energy of the self-generative resonance.

A unique case with [ρ] ring scordatura, [π] microrandom spectra, and [μ] multiplication of multiples (bispectral language) is the duo for oboe d'amore and spectral piano (12 pitches retuned according to harmonics of some spectra) *Animae morte carent* (after Ovid), op. 85 (1995).

Some of the most remote "shadows" of pure harmony and intrinsic spectrality issue from the authentic logic of sound and brain phenomenology. The self-generativity of functions seems to make music itself (in German, the sound phenomena "musizieren").

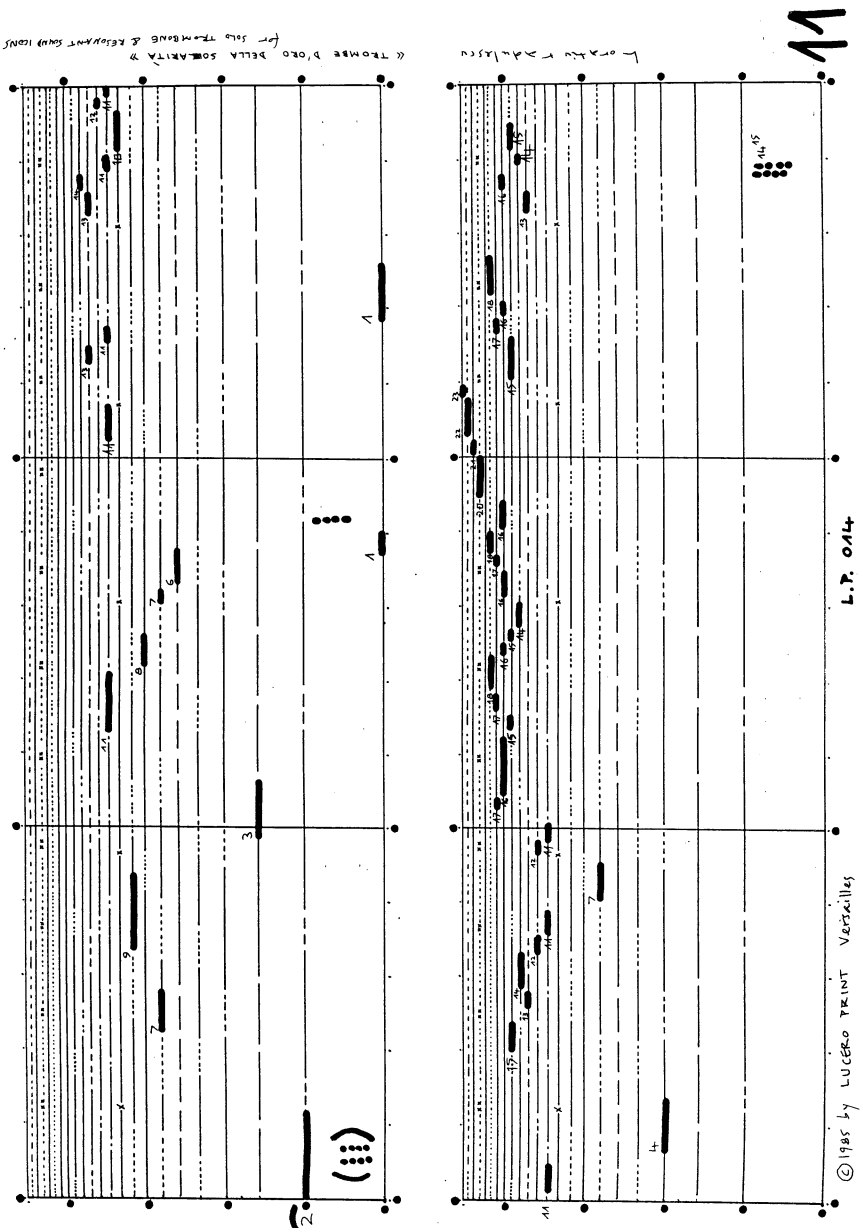

« TROMBE D'ORO DELLA SOLEARITA »
(for solo TROMBONE & RESONANT SOUNDS)
L.P. 014
©1985 by LUCERO PRINT Versailles

FIGURE 18.

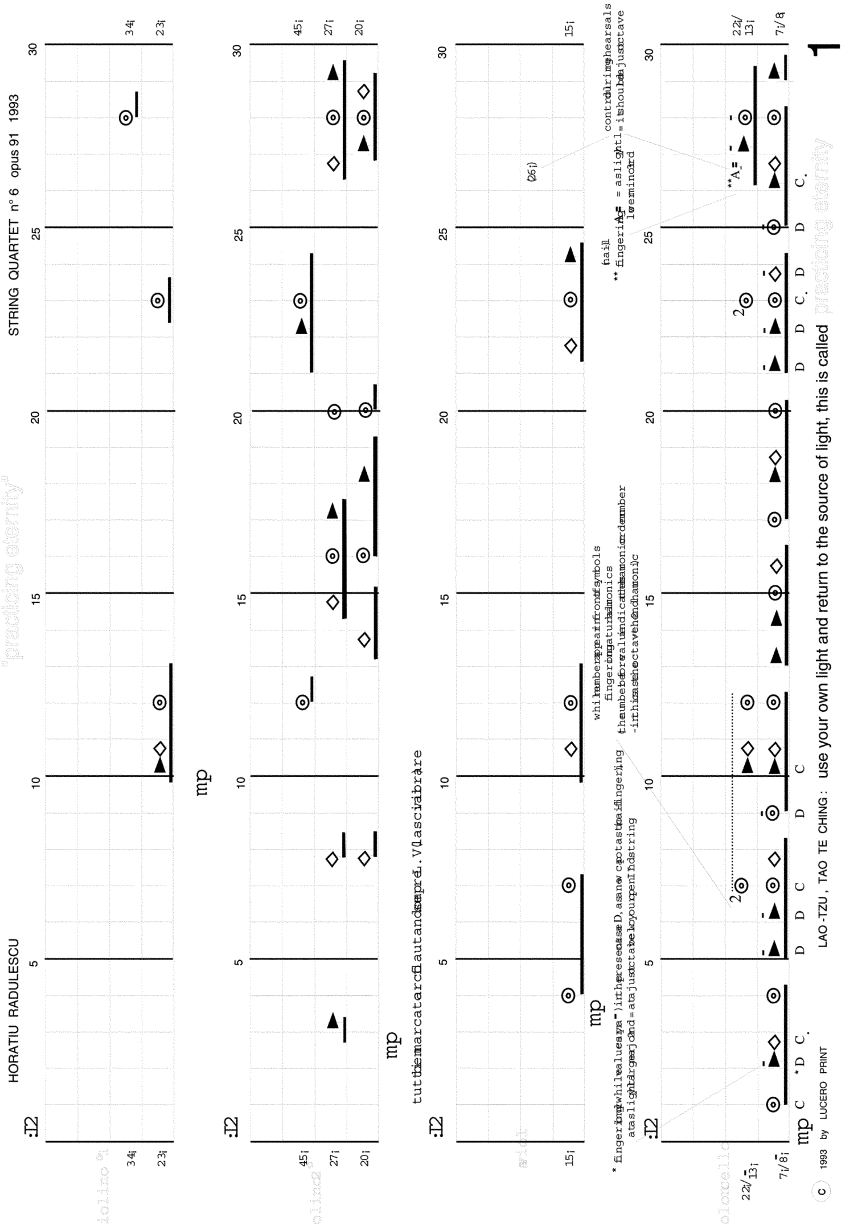

HORATIU RADULESCU
STRING QUARTET n°6 opus 91 1993
"preaching eternity"
violino 1
violino 2
viola
violoncello
mp
LAO-TZU, TAO TE CHING: use your own light and return to the source of light, this is called preaching eternity
1993 by LUCERO PRINT

FIGURE 19.

Complex [ρ] Ring Spectra and Scordatura with Semantic Magic Text Implication

'Before the universe was born,' String Quartet no. 5, op 89 (1990–1995), uses scordaturae covering seven spectra; in addition, the phonetic, notional, and magical significance of the text fragments of Lao-tsu's *Tao te Ching* determine some sound production and performance techniques.

Complex [ρ] Ring Spectra and Scordatura, Plus Explicit/Compact Spectrum [∈], with Microagogic Rhythm, Macrorandom Spectra [Π], and Multiplication of Multiples [μ]

'practicing eternity' (after Lao-tsu), String Quartet no. 6, op. 91 (1992), uses a single scordatura on a D spectrum, with 16 different functions as open strings, producing over 333 pitches: harmonics of those 16 ex-theoretical harmonics, representing 207 different steps of pitch, with a content of 89 totally unique basic spectral functions. The harmonic inquiry reaches utmost phenomenological "alchemy" in between heterohomophony of quasi-birds' chirping and plurimelodic neobyzantine spectral modes of fractal polyphony, the latter being difficult to analyze or reducible to monody, polyphony, homophony, or heterophony (FIG. 19, a page from *'practicing eternity'*).

A ritual of psychoacoustic trance is *Angolo Divino,* op. 87 (1994), for large orchestra where the same 81 microagogic characters of rhythm vivify the sober deployment of macroregister "mobiles" coming from the highest "heaven" and progressively opening on an "Eternal Sight" embracing both highest and lowest "skies" through most secretly murmured and most luminous powerful waves.

TEMPERED ("NONHARMONIC") FORMANTS AS THEORETICAL BASIS OF FUNDAMENTALS WITH INCREASED SPECTRAL CONTENT ("SPECTRUM PULSE")

Already in *'Vies pour les cieux interrompus,'* String Quartet no. 2, op. 6 (1966), *Taaroa* for orchestra, op. 7 (Bucharest 1968–1969), especially in its second movement, "Rivelazione" based on various cluster geology, and *Everlasting longings* for string orchestra: 8, 6, 4, 4, and 2, op. 13 (Paris, 1971), I developed an intense treatment of timbre, highly detailed and producing rich aural information in the second formant: "spectrum pulse" (cf. the theory of composition booklet *Sound plasma–music of the future sign,* written in Paris in 1973, published by Edition Modern Munich in 1975).

Several compositions, op. 8, 9, 11, 12, 14, 15, and 18 (Paris 1969–1973), use *"global sound sources"*: I, instrument/object sound; H, human abstract source; N, natural phenomena; E, electronic sound; L, articulated language, concrete human source, and prepare conceptually the venue of *Capricorn's nostalgic crickets* for seven identical woodwind op. 16h (Grasse 1972–1973) and of *Lamento di Gesù* for large orchestra, op. 23 (Paris, 1973; Munich, 1975). *Capricorn's* pseudo-random reading of a quartertone-based diffracted canon builds 96 rich columns with a very active second formant. This unique sound source reaches the characteristics of all

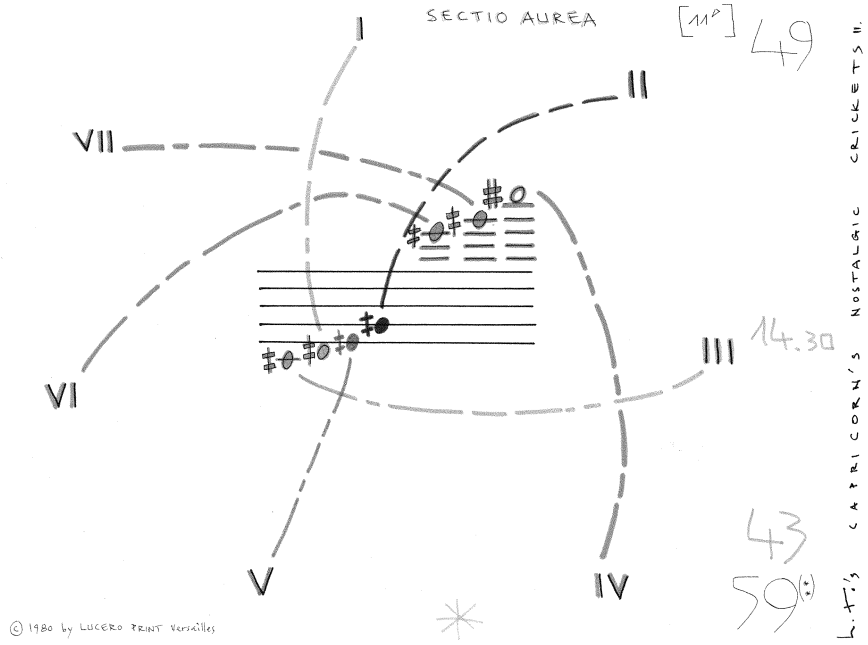


FIGURE 20.

other global sources not present (FIG. 20, 1 of the 96 "eruptions" in *Capricorn's Nostalgic Crickets*).

Lamento di Gesù, op. 23, is a "music on music on silence" where the large aggregates, each of 24 unique functions in quartertones, integrate a horizontal, lying "trinity" from a 7-octave range to a progressively narrowing ambit until the final cluster of the same 24 different pitch plateaus (FIG. 21, a page of *Lamento di Gesù).* Three simultaneous roles of actual, hiding/concealing, and sustaining/echoing source on each of the 24 function orbits make the 91 instruments of the orchestra quite "undetectable." Cause and effect are concealed, as is the Divine, the Eternal.

Other scores use these types of "nonharmonic," tempered, or microtempered fundamentals.

Their "spectrum pulse" is such an intense harmonic sonic life that the "nonharmonic" character (in French, "inharmonique") of these fundamentals' temperament seems to be mostly a very peculiar filtering operating on a harmonic content. One can imagine logarithmic paper being visually filtered in order to become millimetric paper.

In this timbral process of the "emanation of the immanence" we can assume to act conceptually on very high formants of the primal spectrum in order to dispose of enough functions to be able to operate that filtering. The rich "spectrum pulse" of these new fundamentals contributes to unifying all the aural information into a complex multilayered "spectrality."

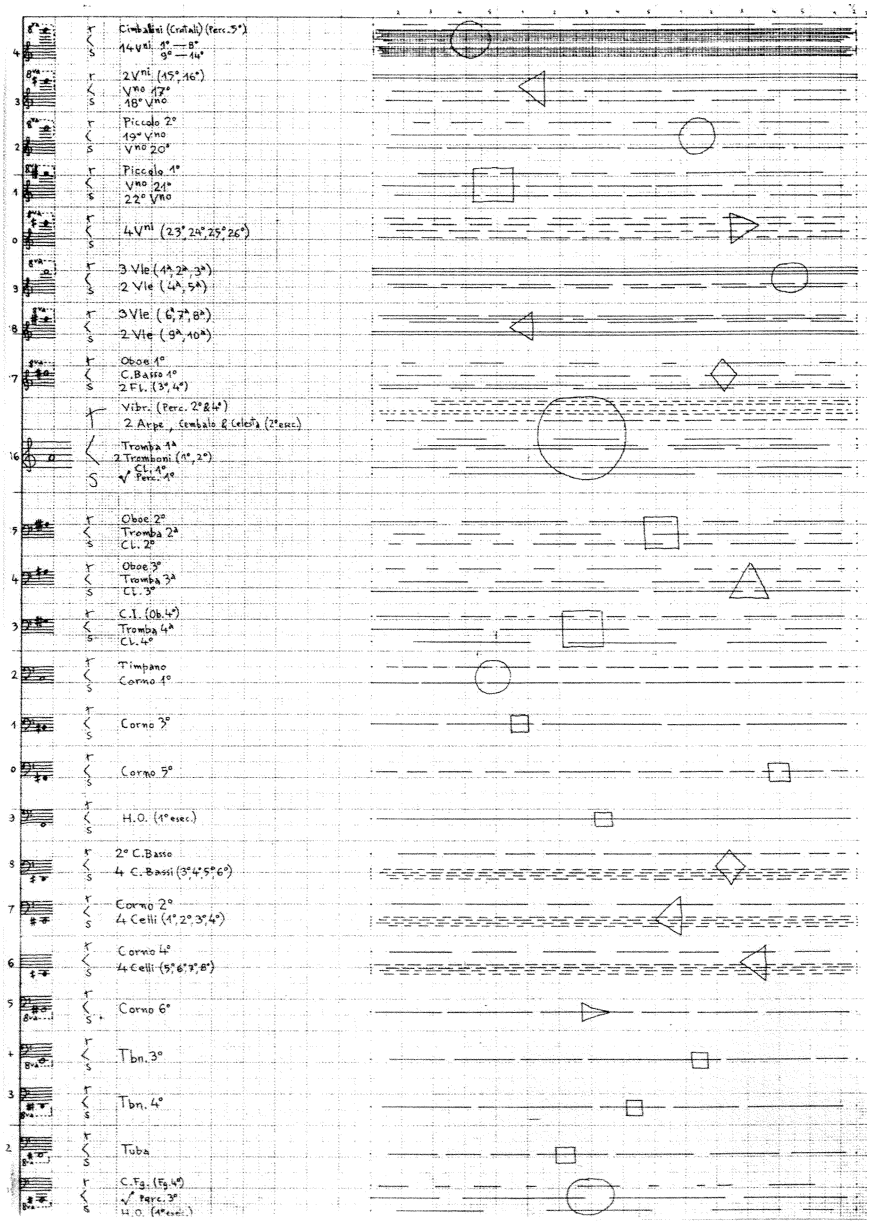


FIGURE 21a.

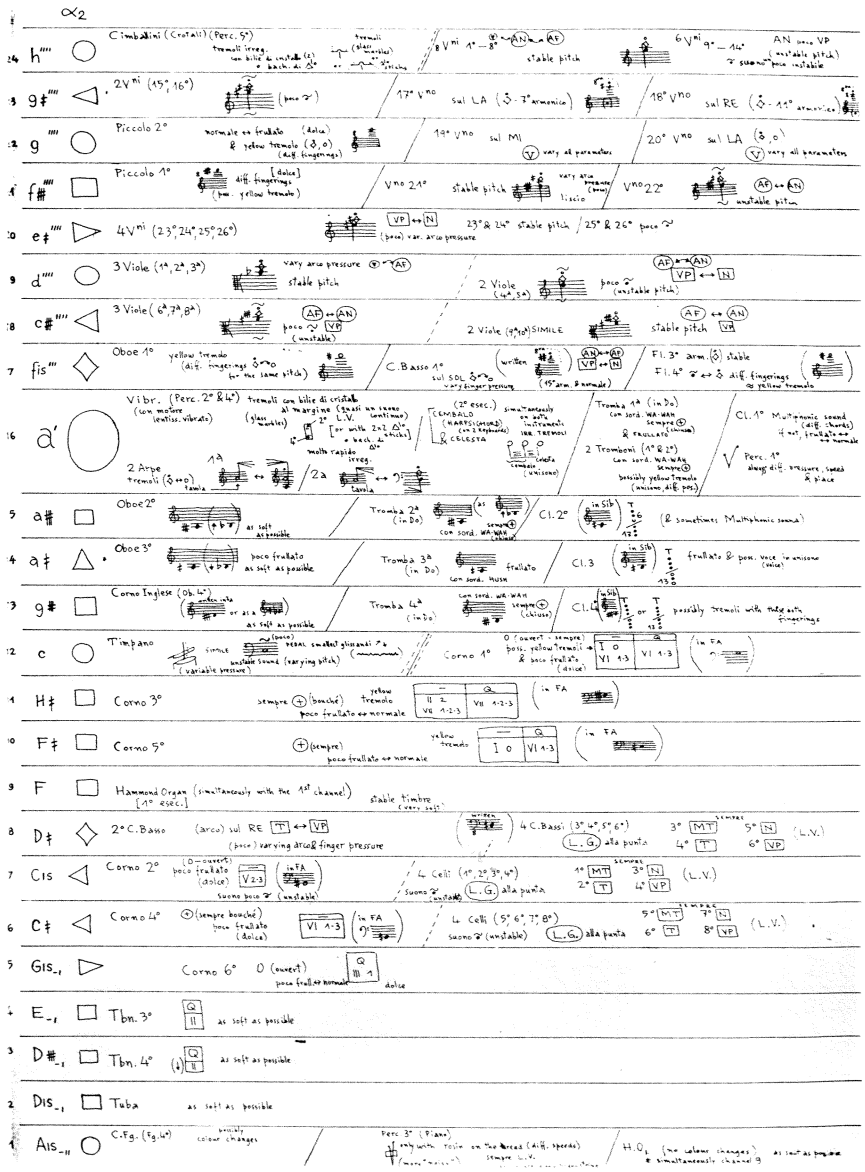


FIGURE 21b.

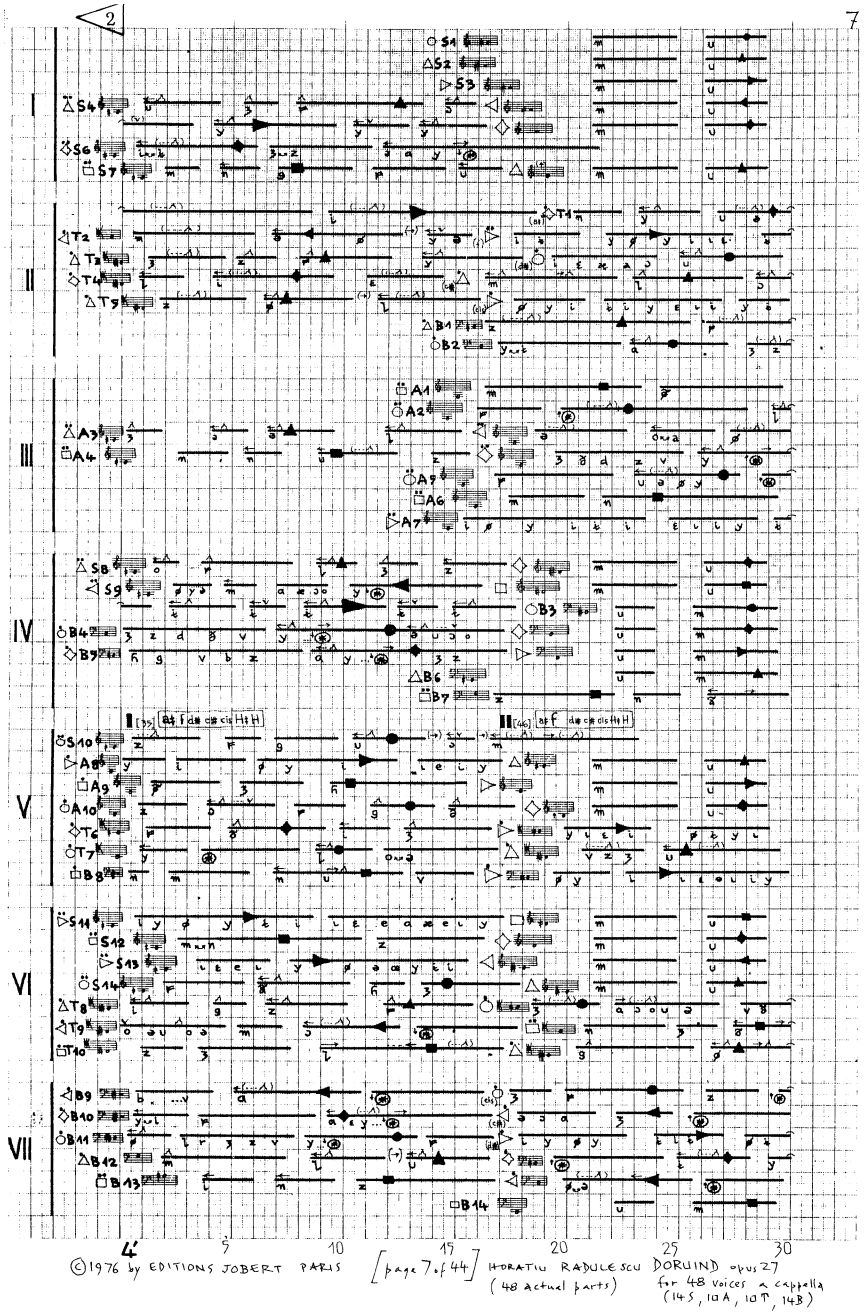

2
7
I
II
III
IV
V
VI
VII
4'
5
10
15
20
25
30
©1976 by EDITIONS JOBERT PARIS
[page 7 of 44]
HORATIU RADULESCU DORUND opus 27
(48 actual parts)
for 48 voices a cappella
(14 S, 10 A, 10 T, 14 B)

FIGURE 22.

A special case is *Doruind* for 48 voices—14, 10, 10, and 14, op. 27 (1976), where the slowest cantus firmus, a row of 24 quartertones deployed only once in 22′, has a unique downhill-uphill registral trajectory and constitutes, with its seven groups of generative sounds, the basis of an advanced ring process (r). For example, one of the middle macroform regions, being based on only two generators, will reach, on the seventh layer of ring modulation. about 250 pitches, simulated through simultaneous singing and whistling of slightly unstable "pitch plateaus." All sounds are live, all being performed *a cappella*—the ring modulation (ρ) of elements of a microtonal tempered scale forces the same problem as in *Lamento di Gesù* to arise in another way: nonharmonic fundamentals (extremely high functions) as the basis of harmonic spectra. However, the preferential self-generative ρ functions attain progressively through successive "auras" of ρ, the perfect, ultimate, and primal state of ε–compact explicit spectrum (FIG. 22, a page of *Doruind*).

ELEMENTS OF TEMPERED ("NONHARMONIC") SCALES IN "PLANETARY" DISPLAY SIMULATE OR APPROXIMATE ACTUAL NONTEMPERED FORMANTS

Self-generative spectral functions (ρ) and explicit compact spectra (ε) are nontempered. Their natural, infinitely varied, microtonal deviation from the tempered scale can be expressed by the tempered pitches of a piano (for example) only through a very strict distribution of the approximate spectral functions at well-respected registral distances.

See the r starting the 2nd Piano Sonata op. 82 "being and non being create each other" (Lao-tzu):

Bb spectrum: 3(6) 4(8) …[7] is not used because too out of tune! …10, 11, … 21 (FIG. 23a.)

Simulation of a compact spectrum (ε) of E (8 functions) and bispectrality through the sudden intervention of some important elements of an F spectrum (4 functions) constitue the opening of the 4th Piano Sonata op. 92 "like a well…older than God" (Lao-tzu):

E spectrum 1, 9, 5, 15, 11, 27, 13, 19

F spectrum 1, 5, 11, 13 (or 27)

… on the late resonance, the E-elements change into F-elements…

(E spectrum 1, 9, 5, 15, 11, 27, 13, 19)

(F spectrum 15, 17, 19, 7, 21, 5, 3, 9)

(See FIG. 23b, first page of "like a well… older than God.")

One of the most advanced approximations of spectral r and e can be found in the second movement, "Sacred Sound, the Second," of *The Quest,* Piano Concerto op. 90 (Freiburg 1996) and in the other versions of "Sacred Sound" in the 4th Piano Sonata and in the Cello Sonata *Exil Intérieur* op. 98 (1997) (FIG. 24, fragment of the Cello Sonata).

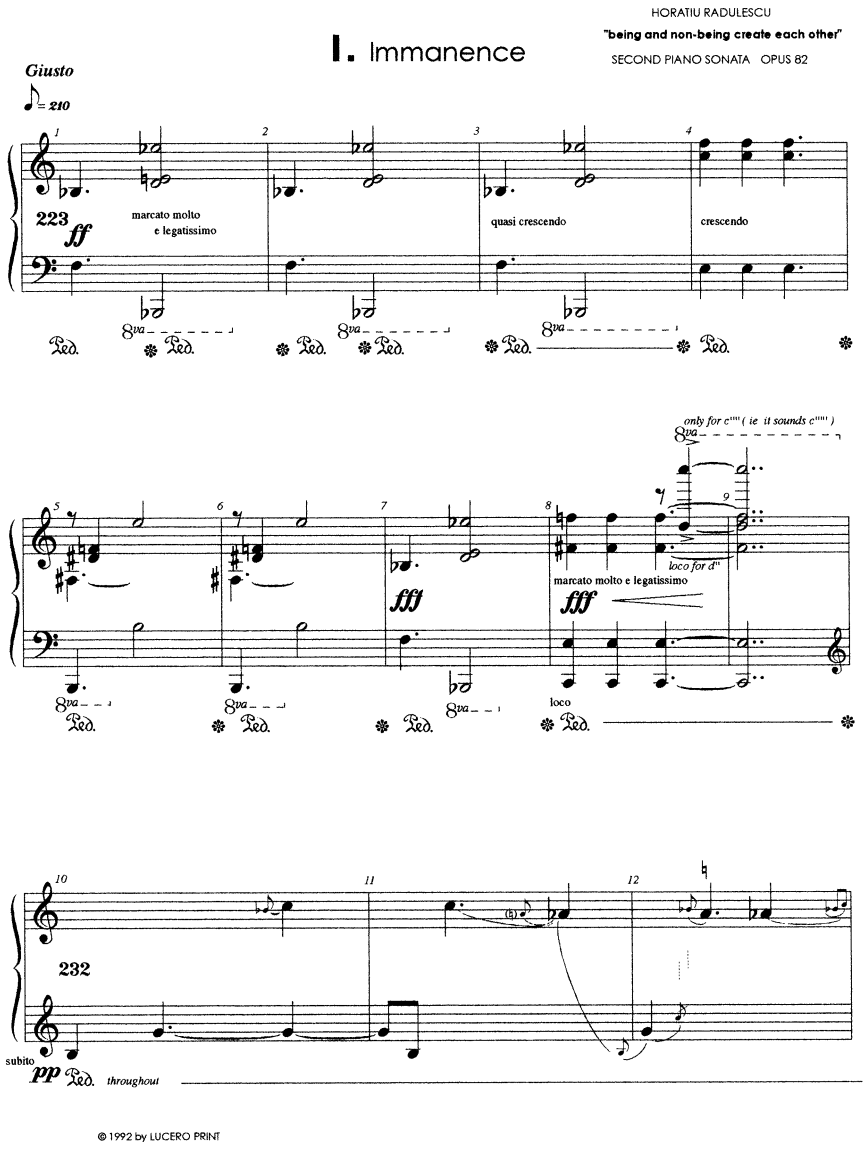

HORATIU RADULESCU
"being and non-being create each other"
SECOND PIANO SONATA OPUS 82
I. Immanence
Giusto
♩= 210
223
ff
marcato molto
e legatissimo
quasi crescendo
crescendo
only for c'''' (ie it sounds c'''')
loco for d''
fff
marcato molto e legatissimo
fff
loco
232
subito
pp
throughout
© 1992 by LUCERO PRINT

FIGURE 23a.


I.
HORATIU RADULESCU
« like a well ... older than God »
piano sonata nr.4 opus 92
trumpets of the eternal
Giusto ♪ = 184
2322 or other permutations of the aksak metric pulse: 2232, 3222, 2223
molto marcato
fff
only resonance, no attack except in the bass
ppp
Ped. throughout
tenuto (resonance)
only resonance, no attack except in the bass
pppp
© 1993 by LUCERO PRINT

FIGURE 23b.


HORATIU RADULESCU CELLO SONATA OPUS 98
II. the sacred sound β
Grave
♩ = 90
I.
II.
Cello
III.
IV.
Piano
ff
fff
pp
8va
loco
subito
sempre
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FIGURE 24.

RANDOM SPECTRALITY

Invented instruments and performances with three types of consciousness—composer, player, amateur (as in *Wild Incantesimo* for nine orchestras, op. 17b)—produce also savage and rich spectra, sometimes containing elements that are difficult to analyze, for example, the "invisible double bass" created by the resonance of sound icons. Forty-four laboratories of sound are encoded by the 44 signs taken from very old civilizations. The performance uses a score of over 4,000 colored slides projected onto 19 cinema screens encircling the audience. Over 4,000 micromusic events are realized by the 162 players (18 per orchestra) in 112 minutes.

Other cases of random spectrality are found in *Astray* for two duos of sound icons and saxophones, where the macroform is read at three speeds on two simultaneous layers, approaching psychoacoustically the problem of "presentiment of remembrances;" also, the recitation in 42 languages in *Hierophany,* op. 16r, with 42 children arrives at pitched abstract colored noise from the multilingual magic, notional, phonetic "alchemy" of a unique poem.

SPACE AS TIME OF SPECTRAL RITUALS

To combine the compass of sound (element, width, sound, and noise) and that of the psyche (thought, feeling, intuition, and sensation), the sound sources such as the 9 celli in *Credo* and *Ultimo Credo*, the 34 (or 340) children's voices in *Do Emerge Ultimate Silence,* the 9 orchestras in *Wild Incantesimo,* the 40 flautists with 72 flutes in *Byzantine Prayer*, the 9 string quartets in *'Infinite to be cannot be infinite, infinite anti-be could be infinite',* the 7 groups in *Mirabilia Mundi,* the revolving gongs in *Outer Time,* and the "ethereal harp" of the 7 clarinets in *Inner Time*, the sound icons of *A Doini* or of *Clepsydra,* are living in the temple of time, and bring us the movement and the vibration of light.