

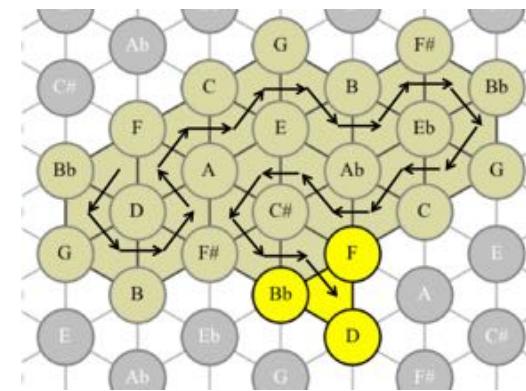
Strips, Clocks and Donuts in contemporary (art) music and song writing



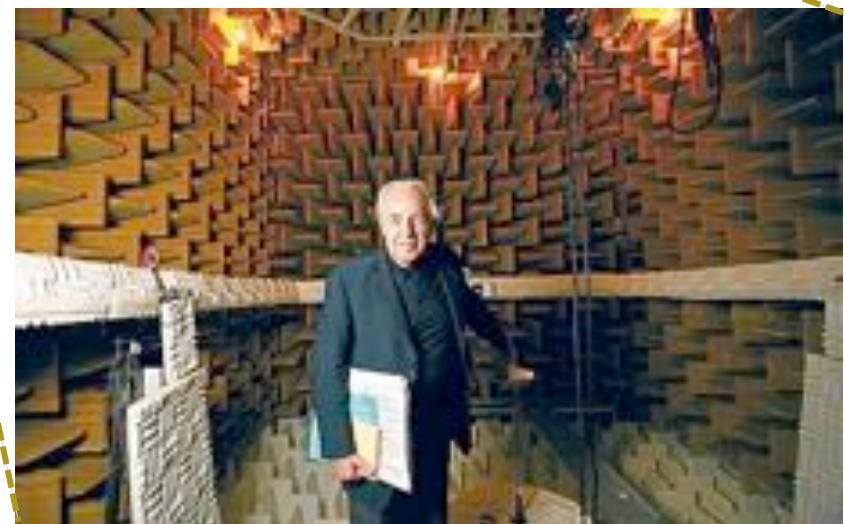
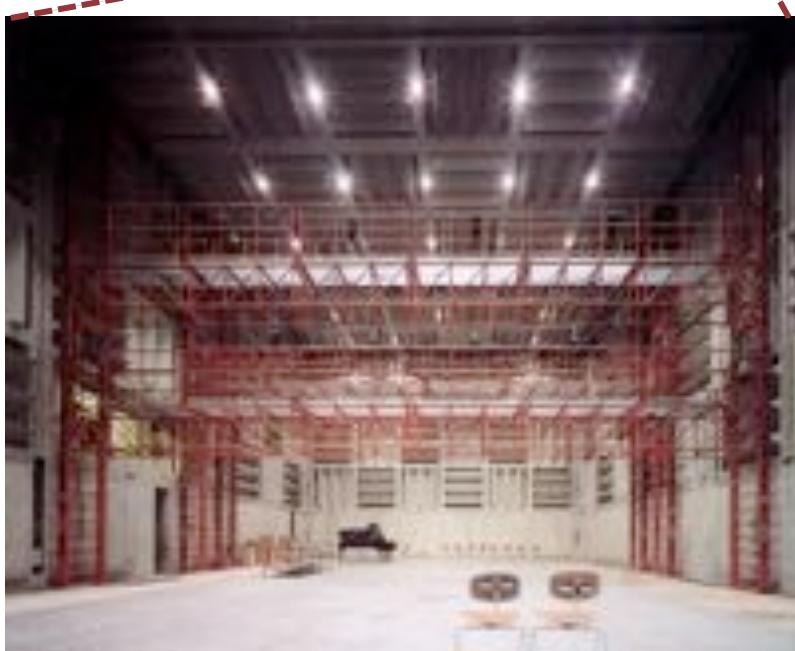
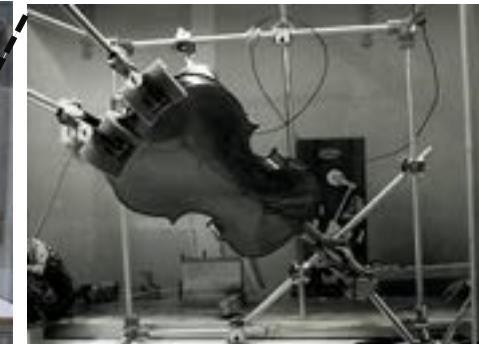
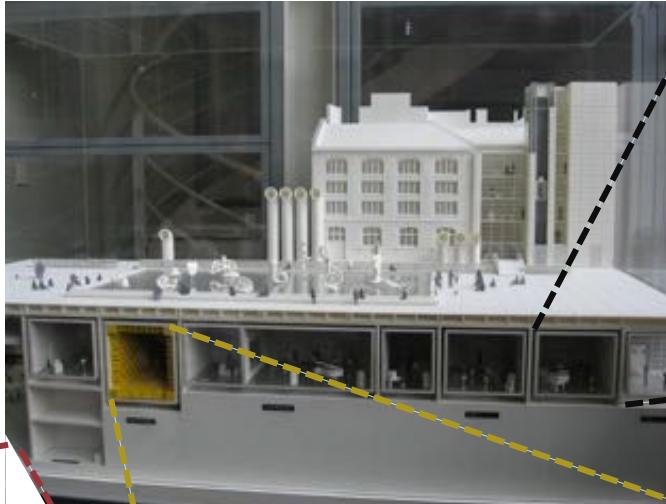
BergamoScienza

24 June 2017

Moreno Andreatta
Music Representations Team
IRCAM / CNRS UMR 9912 / UPMC, Paris
IRMA & GREAM, University of Strasbourg
Moreno.Andreatta@ircam.fr



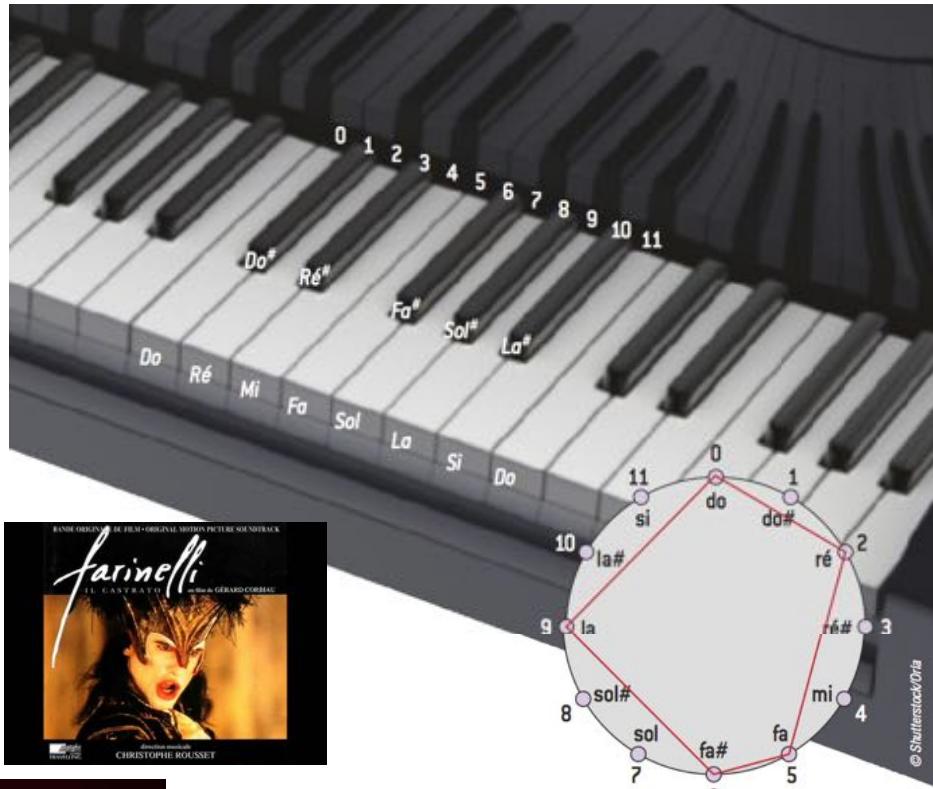
The musical and scientific research at IRCAM...



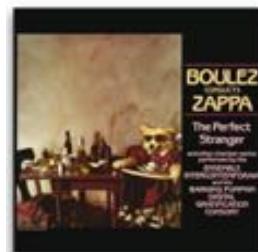
... at the interface between contemporary and pop music



MusiqueLab 2

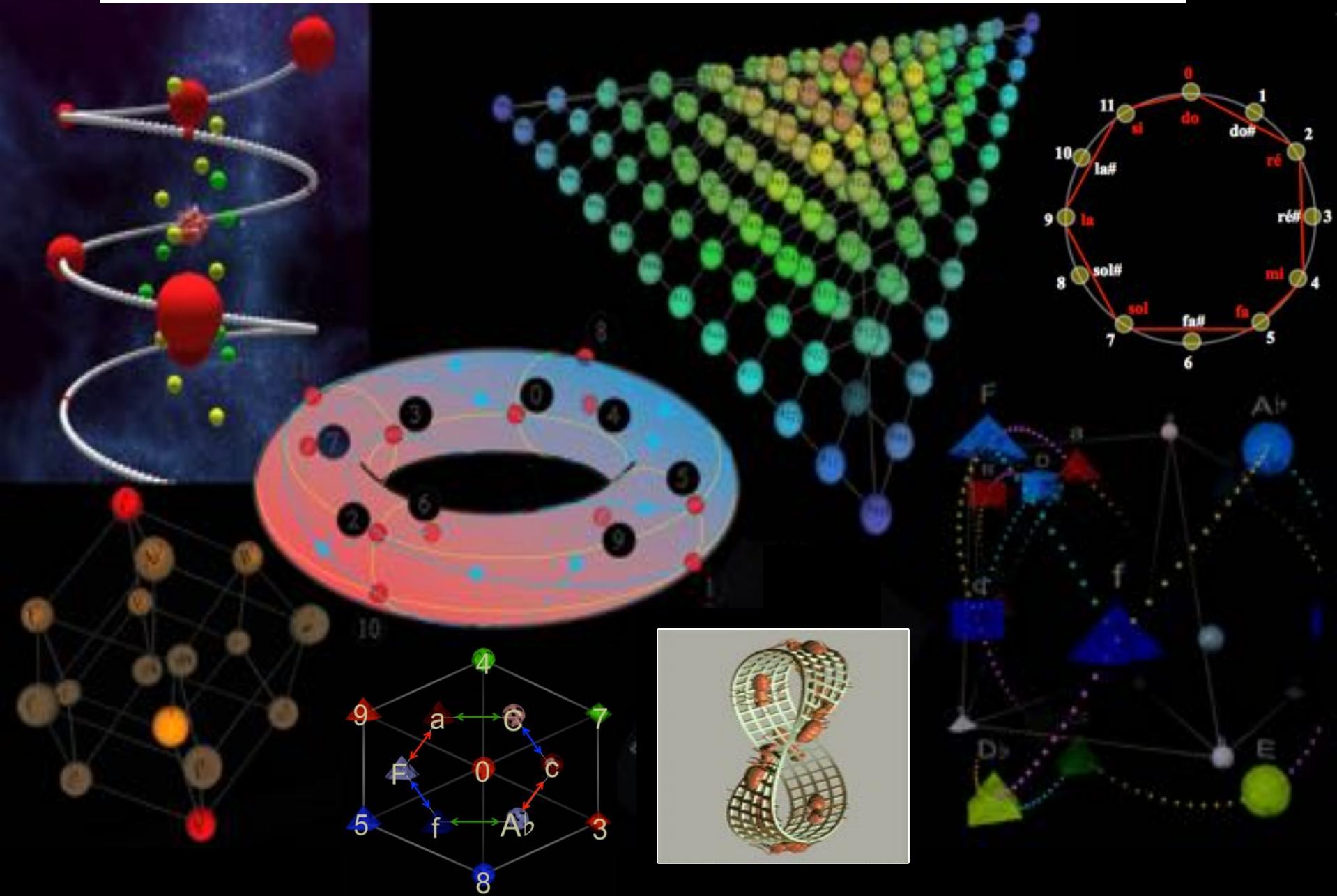


OMAX (computer-aided impro)

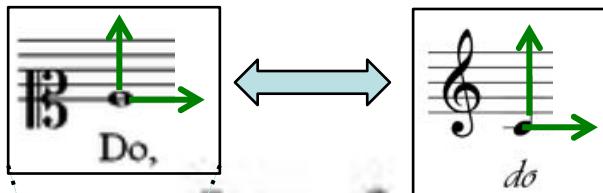
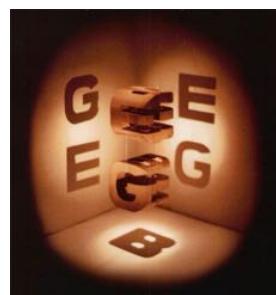


www.ircam.fr

The galaxy of geometrical models at the service of music

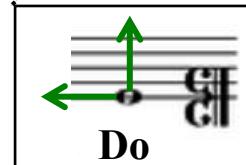
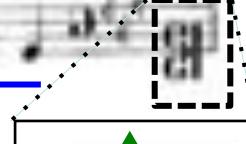


Bach's enigmatic canons and geometry



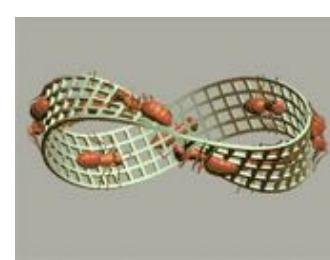
Canones diversi
super thema regium

Canon a 2.





My end is my beginning (but twisted!)



Canones diversi

super thema regium

1.

Canon n. 2

1. Canon n. 2

...

Canones diversi
super thema regium

Canon n. 2

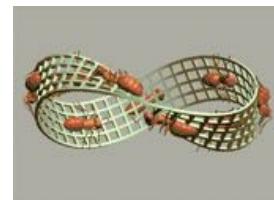
4.

4.

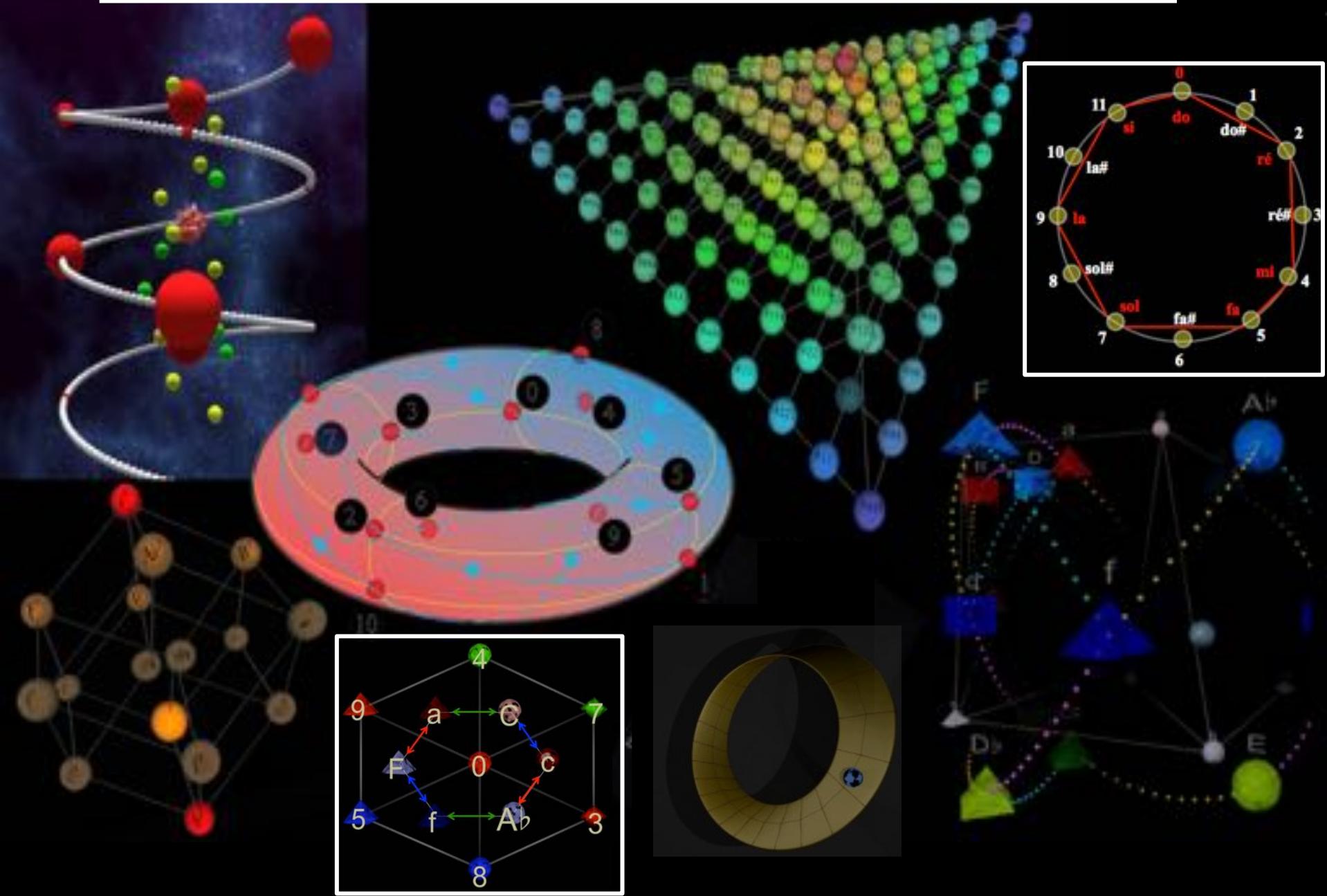


<http://www.josleys.com/Canon/Canon.html>

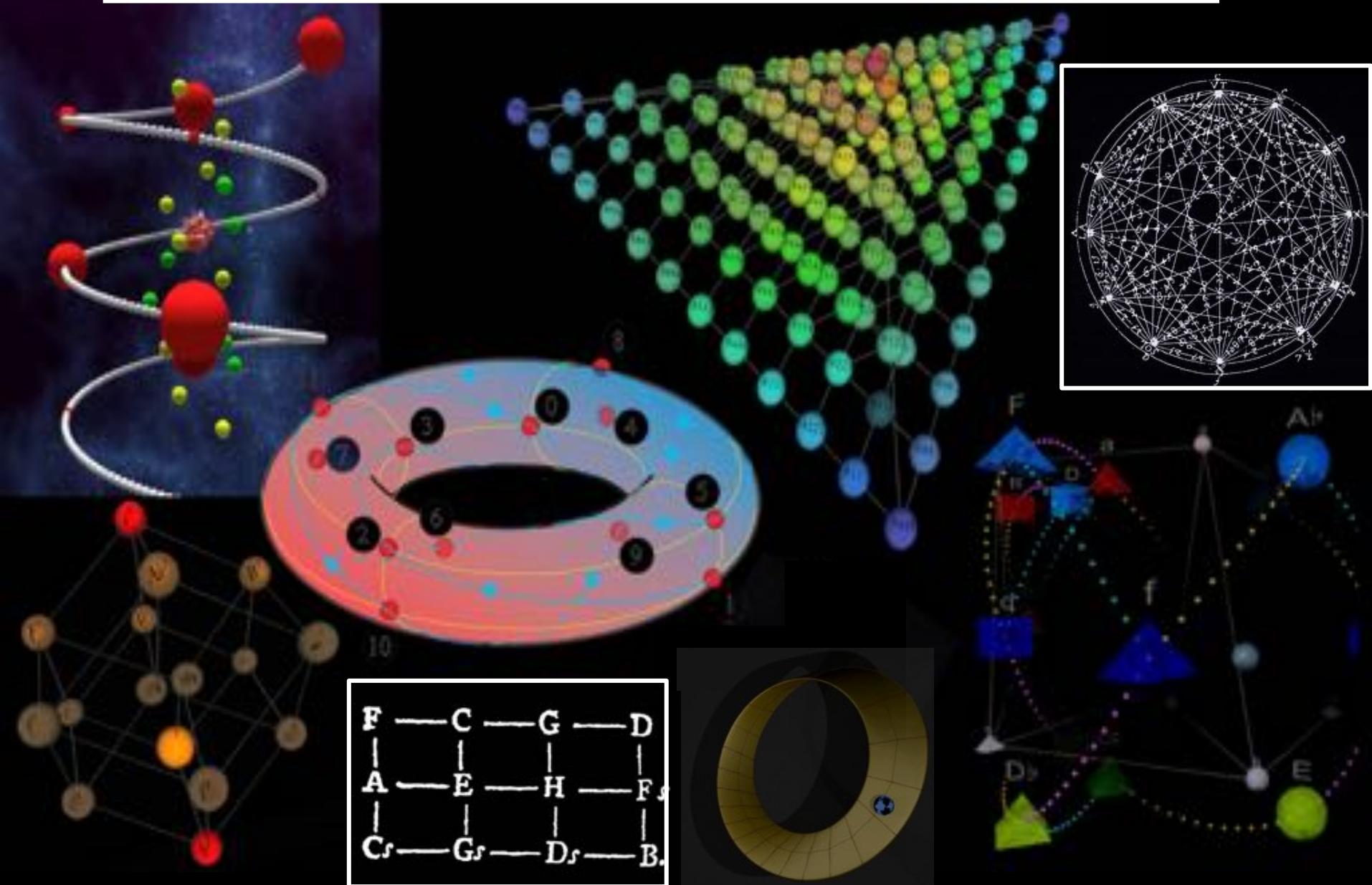
[min. 1'14"]



The galaxy of geometrical models at the service of music

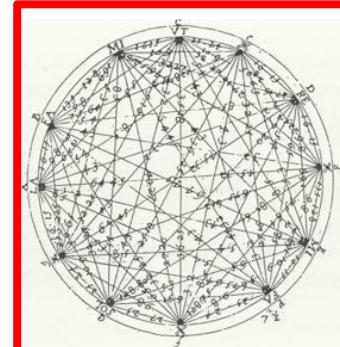


The galaxy of geometrical models at the service of music

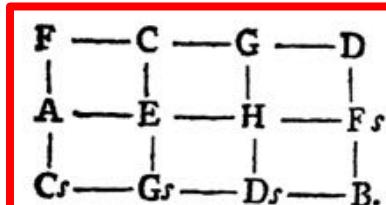


Music and mathematics: « prima la musica »!

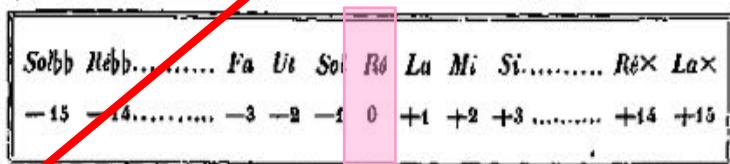
| MUSIQUE | MATHS |
|--|--|
| 500 av. J. C. Relation hauteur/longueur corde. La musique est source d'inspiration pour la théorie des nombres et la géométrie. <i>Pas de correspondance musicale.</i> | Nombres naturels et rationnels. |
| 300 a.J. Invention (théorique) de la gamme chromatique tempérée égale par Aristoxénos de Tarente) et prémonition de la théorie des groupes. Isomorphismes entre les logarithmes (intervalles musicaux) et les exponentiels (longueur d'une corde). | Nombres irrationnels, théorème de Pythagore. Les mathématiques ne réagissent pas. |
| 1000 ap. J.C. Invention de la représentation bidimensionnelle des hauteurs. | Aucune correspondance. |
| 1500 Aucune reprise des concepts précédents. | Nombres négatifs. Construction des rationnels. |
| 1600 Aucune relation. | Nombres réels et les logarithmes. Invention des repères cartésiens. |
| 1648 Marin Mersenne : invention de la combinatoire musicale (<i>Harmonicorum Libri</i>) | Systématisation du calcul des probabilités par Bernoulli (<i>Arz Conjectandi</i> , 1713) |
| 1700 La fugue comme un automate abstrait. Manipulation inconsciente du groupe de Klein. | Nombres complexes (Euler, Gauss), les quaternions (Hamilton), continuité (Cauchy), structure de groupe (Galois, Abel). |
| 1773 Leonhard Euler : représentation géométrique des hauteurs (<i>Speculum Musicum</i>) | Invention de la théorie des graphes |
| 1855 Camille Durutte : analyse harmonique, rythmique et mélodique | Développement en série d'une fonction (Wronski) |
| 1900 Libération de la prison de la tonalité (Loquin, Hauer, Schoenberg). | Nombres infinis et transfinis (Cantor). Axiomatique de Peano. Théorie de la mesure (Lebesgue, Borel). |
| 1920 Formalisation radicale des macrostructures à travers le système sériel (Schoenberg). | Aucun développement de la théorie des nombres. Logique (contradictions de la théorie des ensembles). |
| 1937-1939 Ernst Krének : les axiomes en musique | David Hilbert, <i>Les fondements de la géométrie</i> (1899) |
| 1946 Milton Babbitt : théorie des groupes et système dodécaphonique | Rudolf Carnap, <i>The Logical Syntax of Language</i> (1937) |



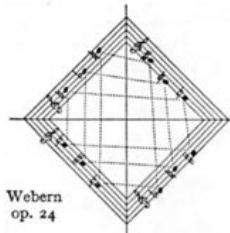
Mersenne,
*Harmonicorum
Libri XII*, 1648



Euler, *Speculum
musicum*, 1773



Durutte, *Technie, ou lois générales du système harmonique* (1855)



| S | I | R | RI |
|----|----|----|----|
| S | S | I | RI |
| I | I | S | RI |
| R | R | RI | S |
| RI | RI | R | I |

Krenek and Babbitt, twelve-tone method, axiomatics and Klein group



Iannis Xenakis

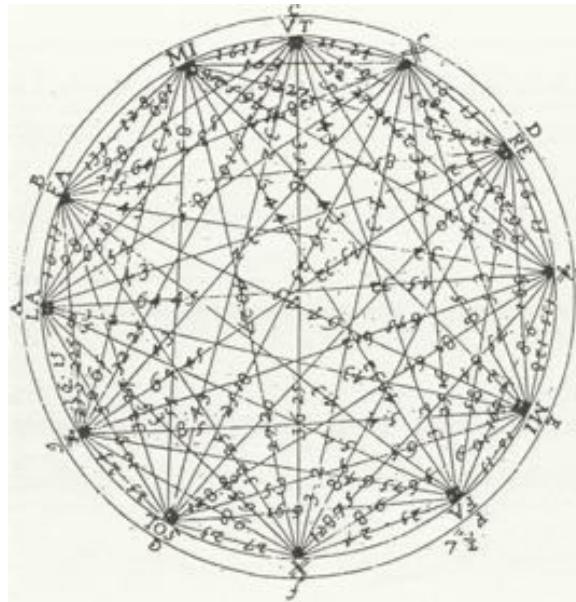
Mersenne and the birth of (musical) combinatorics

II4 Marin Mersenne, *Harmonicorum Libri XII*, 1648

LIBER SEPTIMVS. DE CANTIBVS, SEV CANTILENIS, EARVMQ; NVMERO, PARTIBVS, ET SPECIEBVS.

Tabela Combinationis ab I ad XXII.

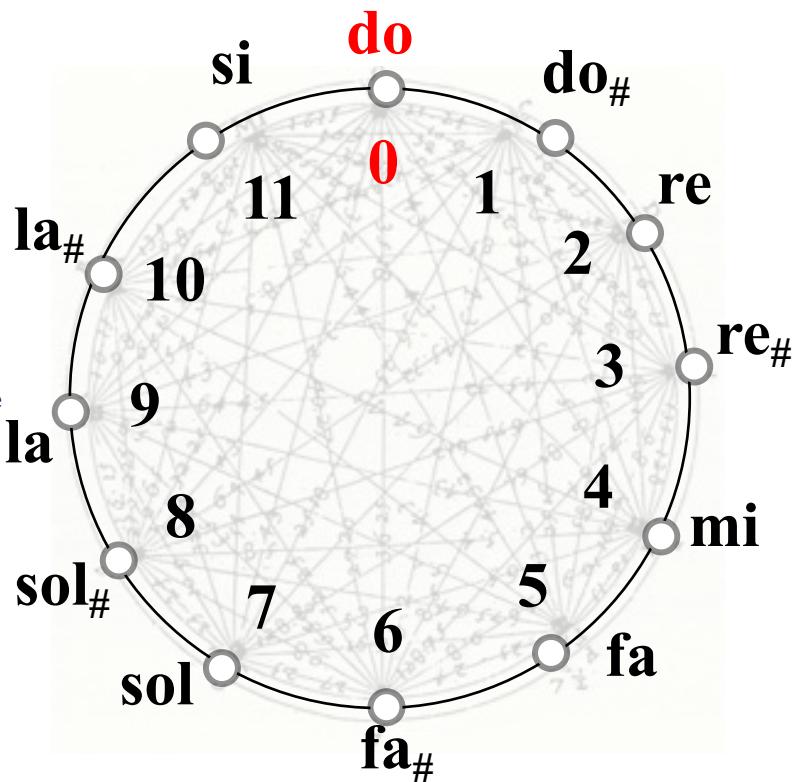
| | |
|-------|-----------------------|
| I | 1 |
| II | 2 |
| III | 6 |
| IV | 24 |
| V | 120 |
| VI | 720 |
| VII | 5040 |
| VIII | 40320 |
| IX | 362880 |
| X | 3628800 |
| XI | 39916800 |
| XII | 479001600 |
| XIII | 6117020800 |
| XIV | 8717819200 |
| XV | 1107674368000 |
| XVI | 10933789888000 |
| XVII | 311687418296000 |
| XVIII | 6401573705718000 |
| XIX | 11164100040818000 |
| XX | 1433904008176640000 |
| XXI | 31090941171709440000 |
| XXII. | 384000737777607680000 |



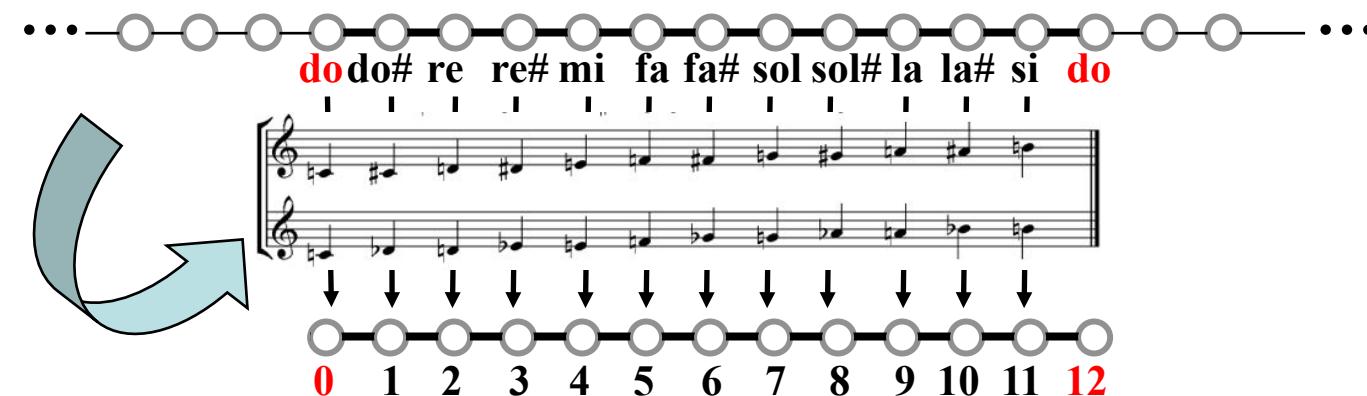
Marin Mersenne



The circular representation of the pitch space



Harmonicorum Libri XII, 1648



→ DEMO

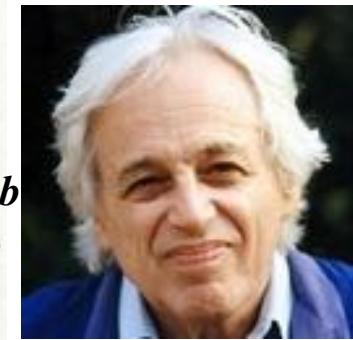
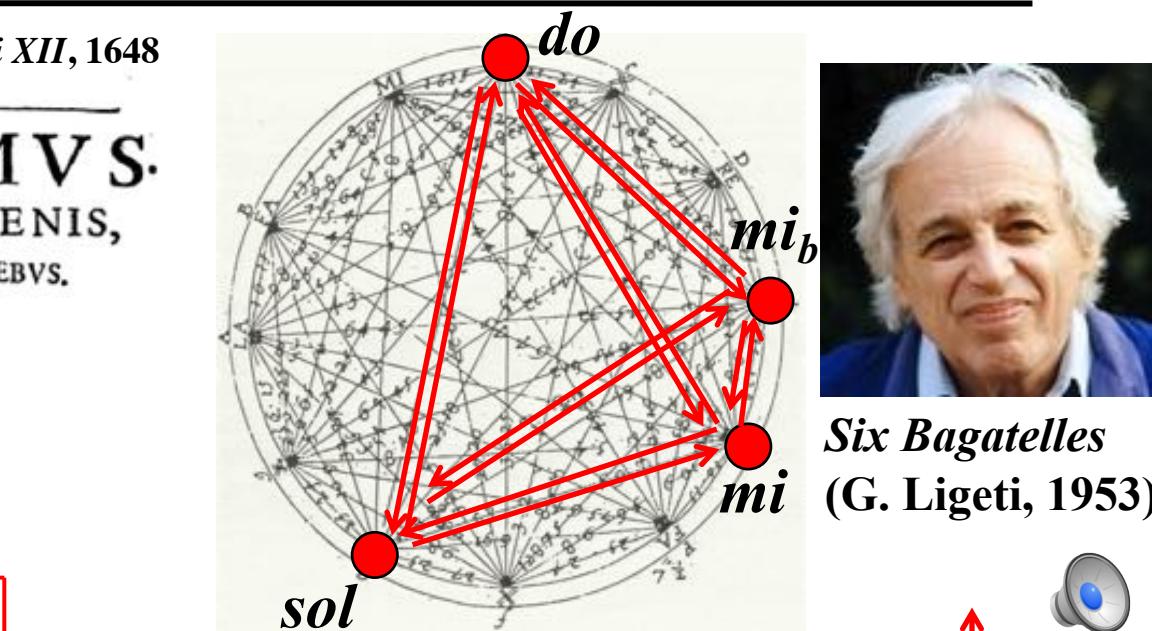
Permutational melodies in contemporary (art) music

II.4 Marin Mersenne, *Harmonicorum Libri XII*, 1648

LIBER SEPTIMVS. DE CANTIBVS, SEV CANTILENIS, EARVMQ; NVMERO, PARTIBVS, ET SPECIEBVS.

Tableta Combinationis ab I ad XXI.

| | |
|-------|------------------------|
| I | I |
| II | II |
| III | 6 |
| IV | 24 |
| V | 120 |
| VI | 720 |
| VII | 5040 |
| VIII | 40320 |
| IX | 361800 |
| X | 3618000 |
| XI | 39916800 |
| XII | 479001600 |
| XIII | 6117010800 |
| XIV | 87178191200 |
| XV | 1107674568000 |
| XVI | 10922789888000 |
| XVII | 311687418296000 |
| XVIII | 6401173705718000 |
| XIX | 11164100040813000 |
| XX | 1433904008176640000 |
| XXI | 51090941171709440000 |
| XXII. | 1884000737777607680000 |



Six Bagatelles
(G. Ligeti, 1953)

A musical score titled 'Varietas, seu Combinatio quatuor notarum.' It consists of two staves of music. The top staff has 12 numbered measures (1 through 12). The bottom staff has 12 numbered measures (13 through 24). The music is composed of short, rhythmic patterns of eighth and sixteenth notes. A red arrow points from the number 24 in the table on the left to the number 24 in the score on the right.



Permutational melodies in song writing

Se telefonando, 1966 (Maurizio Costanzo/Ennio Morricone) / Mina

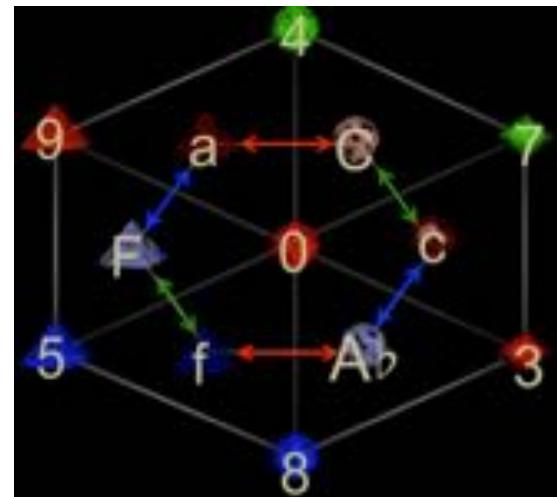


(min. 0'53")



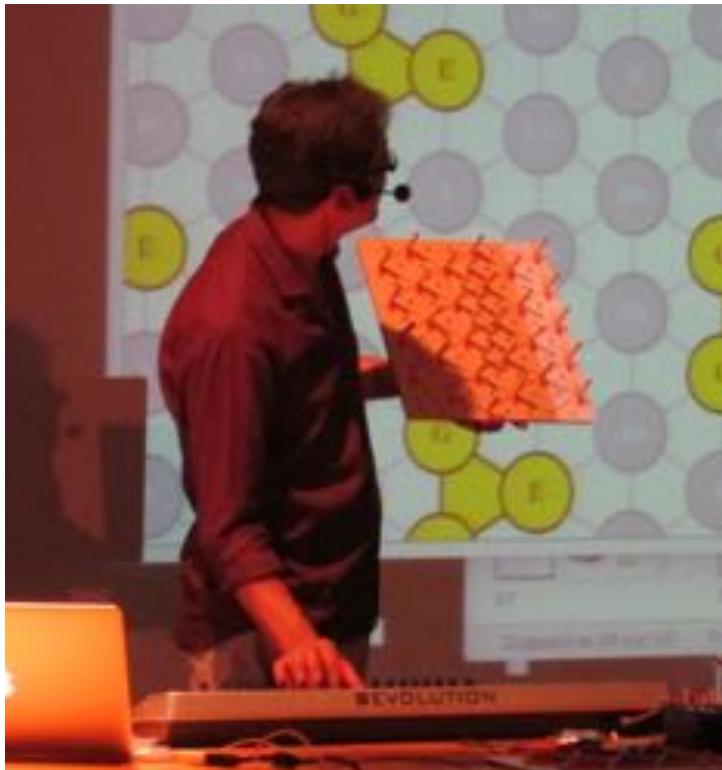
Ennio Morricone

The harmonic space



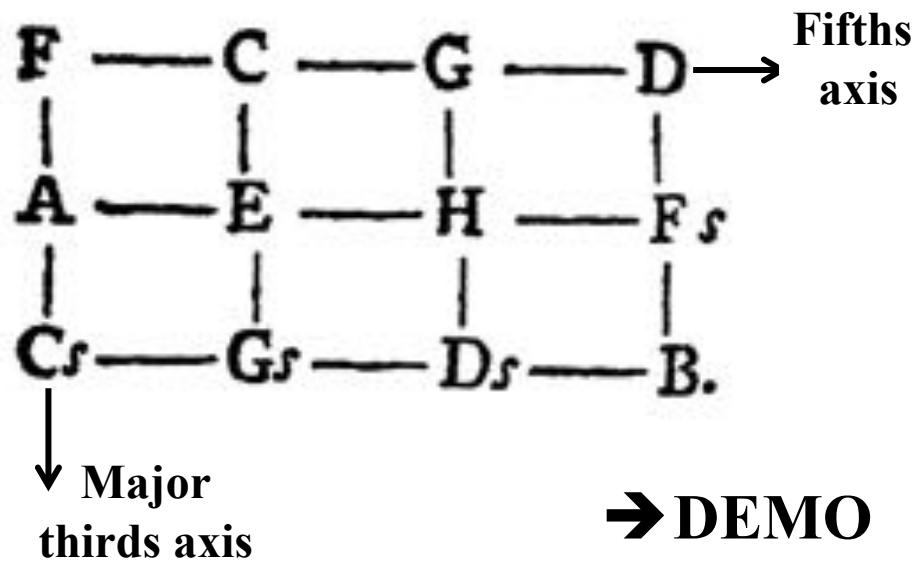
| | | | | | |
|----------------|----------------|----------------------|----------------------|----------------|----------------|
| C | c | C_# | c _# | D | d |
| E _b | e _b | E | e | F | f |
| F _# | f _# | G | g | G _# | g _# |
| A | a | B_b | b_b | B | b |

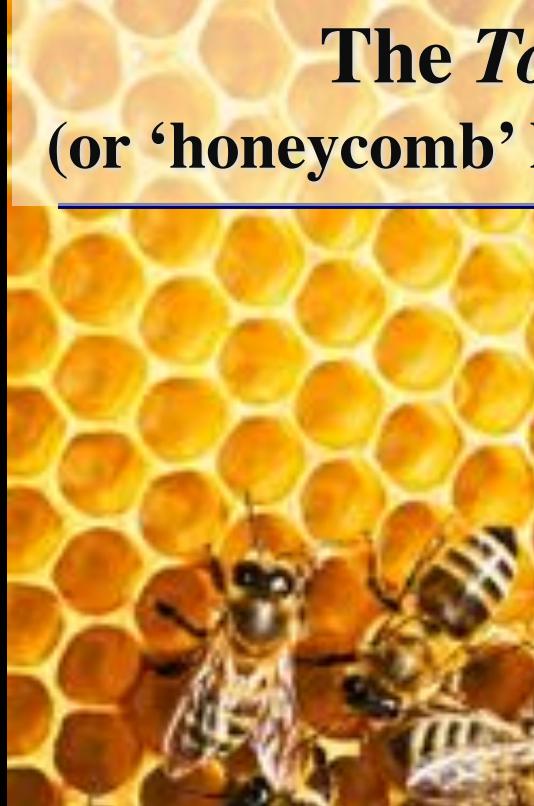
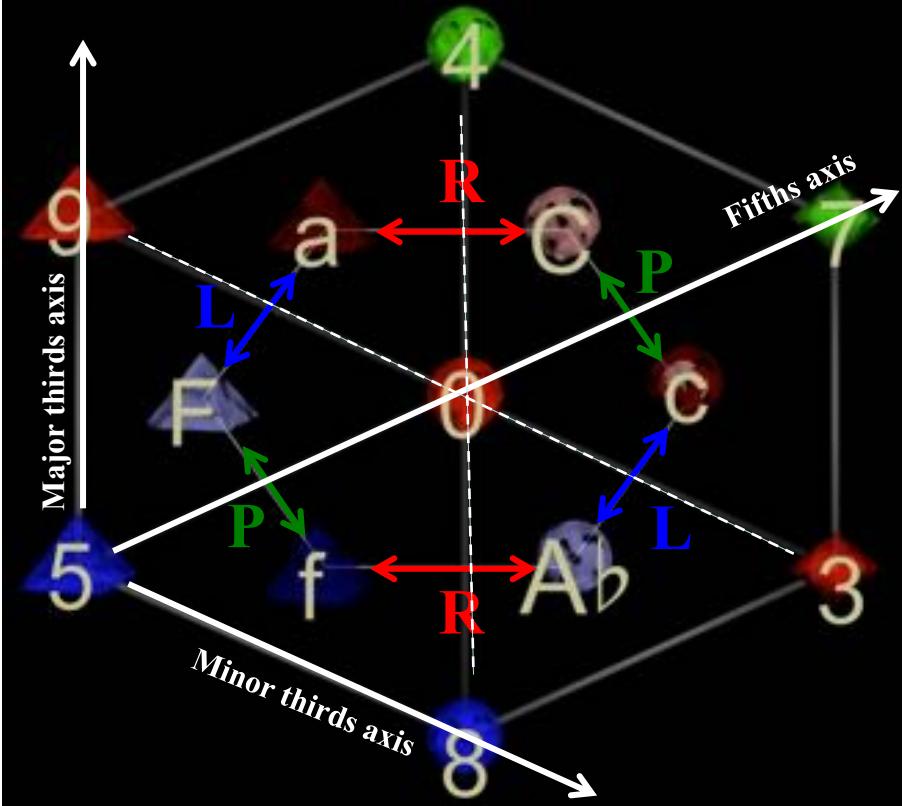
Chord enumeration



The Tonnetz

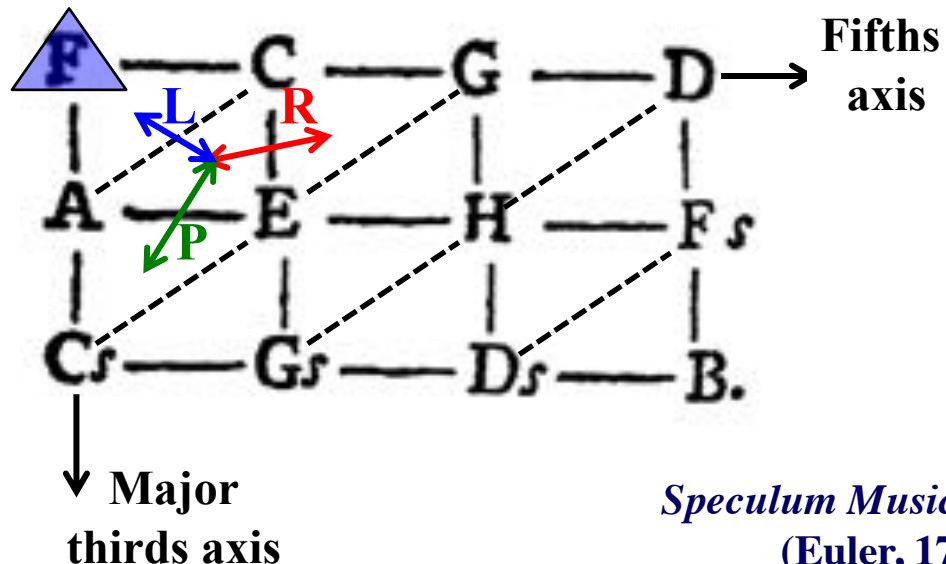
(or ‘honeycomb’ hexagonal tiling)





The Tonnetz

(or ‘honeycomb’ hexagonal tiling)



Speculum Musicum
(Euler, 1773)



Two Dimensions

Traditional Chordal Space

© Gilles Baroin 2011



Gilles Baroin

→ www.mathemusic.net

Harmonic Progressions

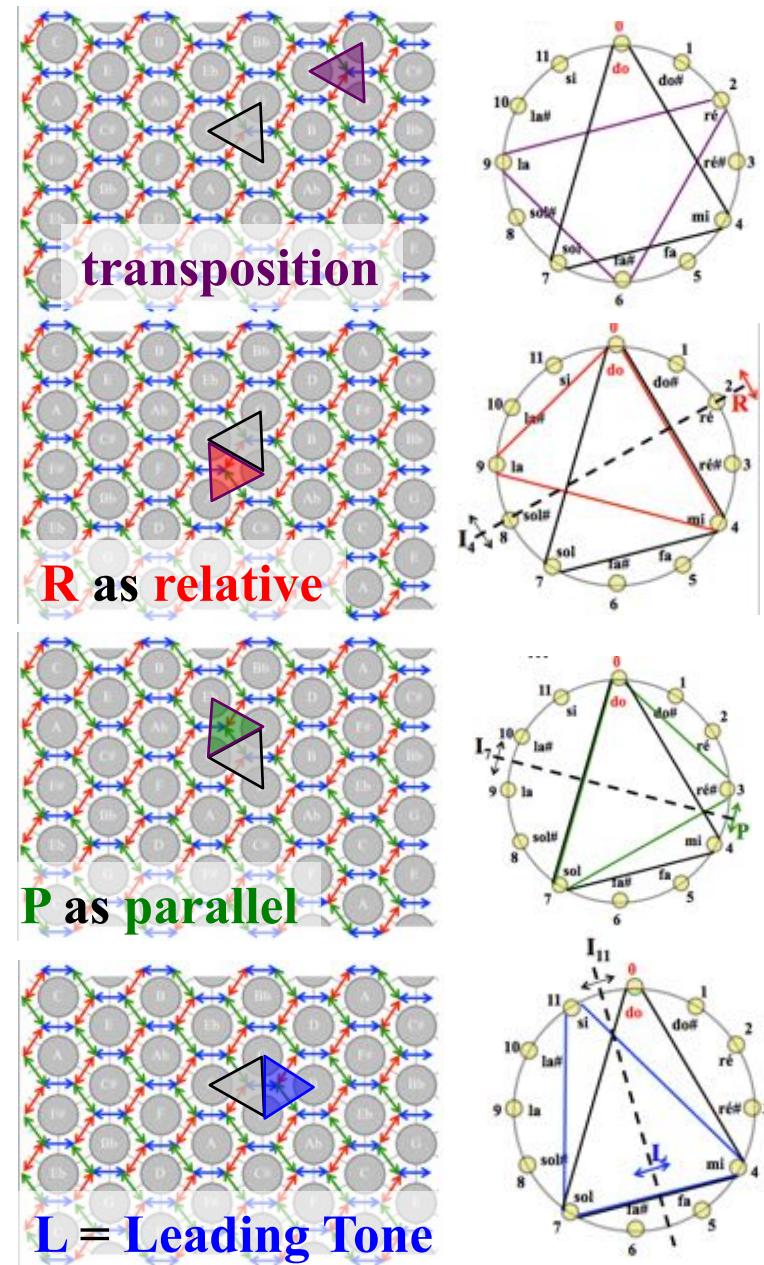
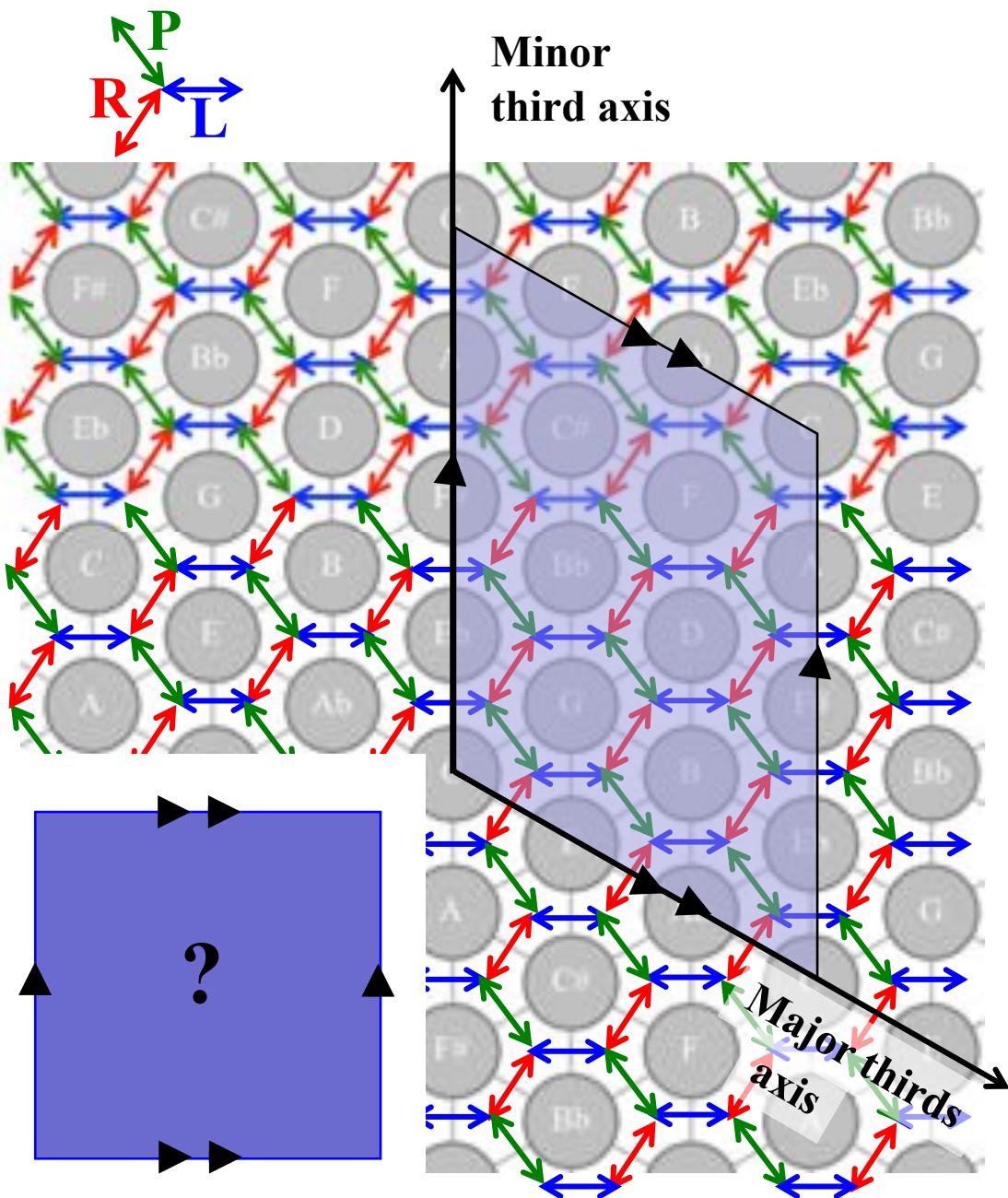
In Paolo Conte

Sotto le Stelle del Jazz

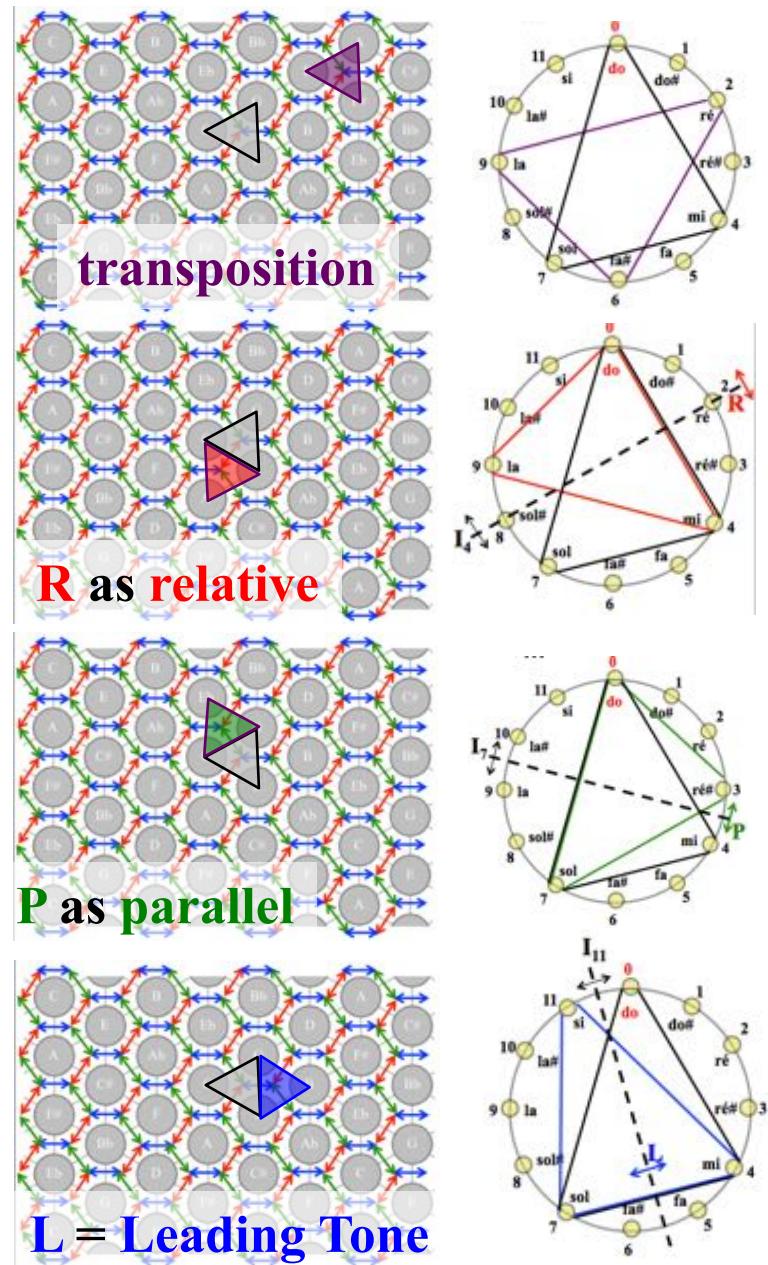
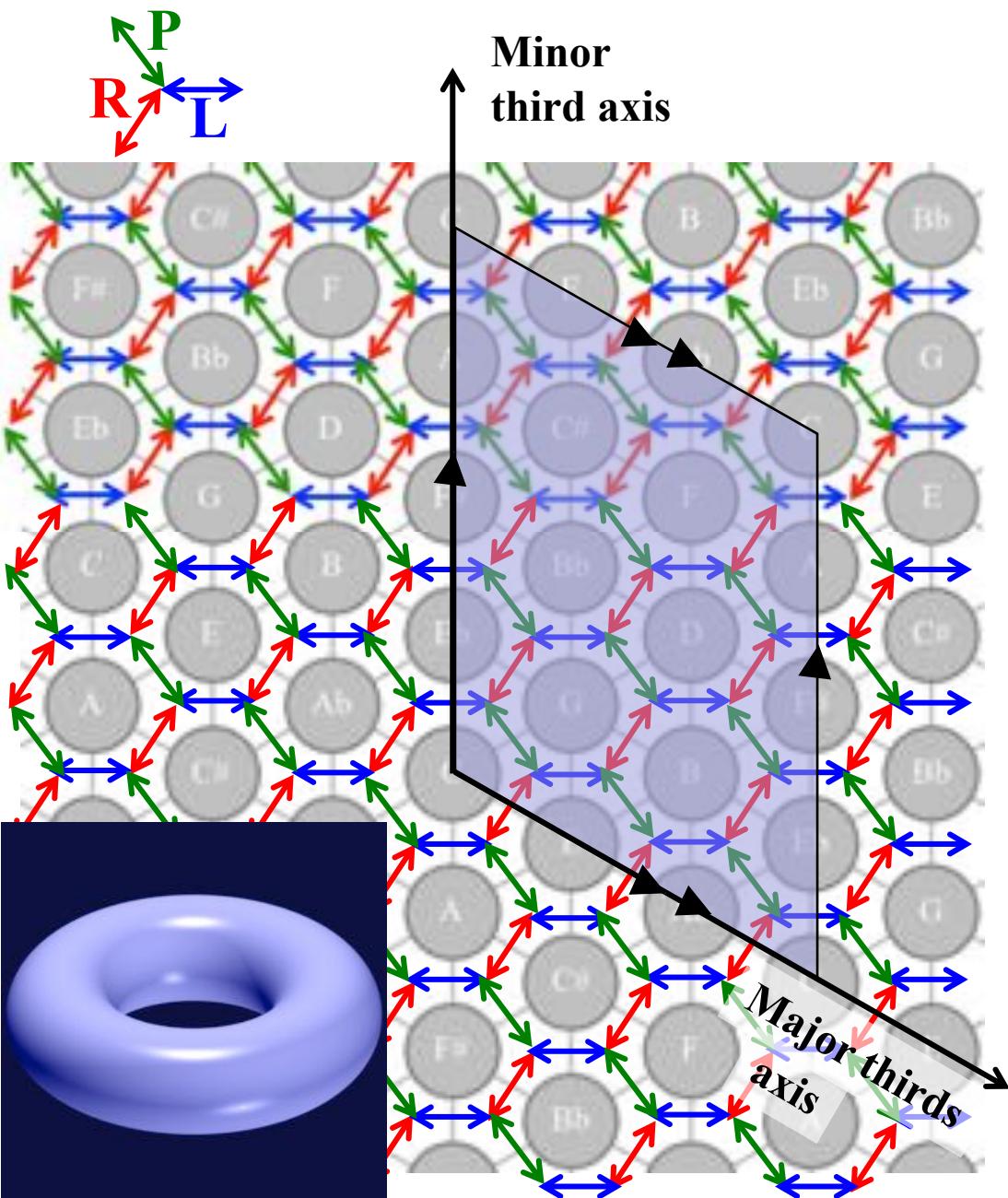


*Supervision Moreno Andreatta
Modelisation Gilles Baroin 2016*

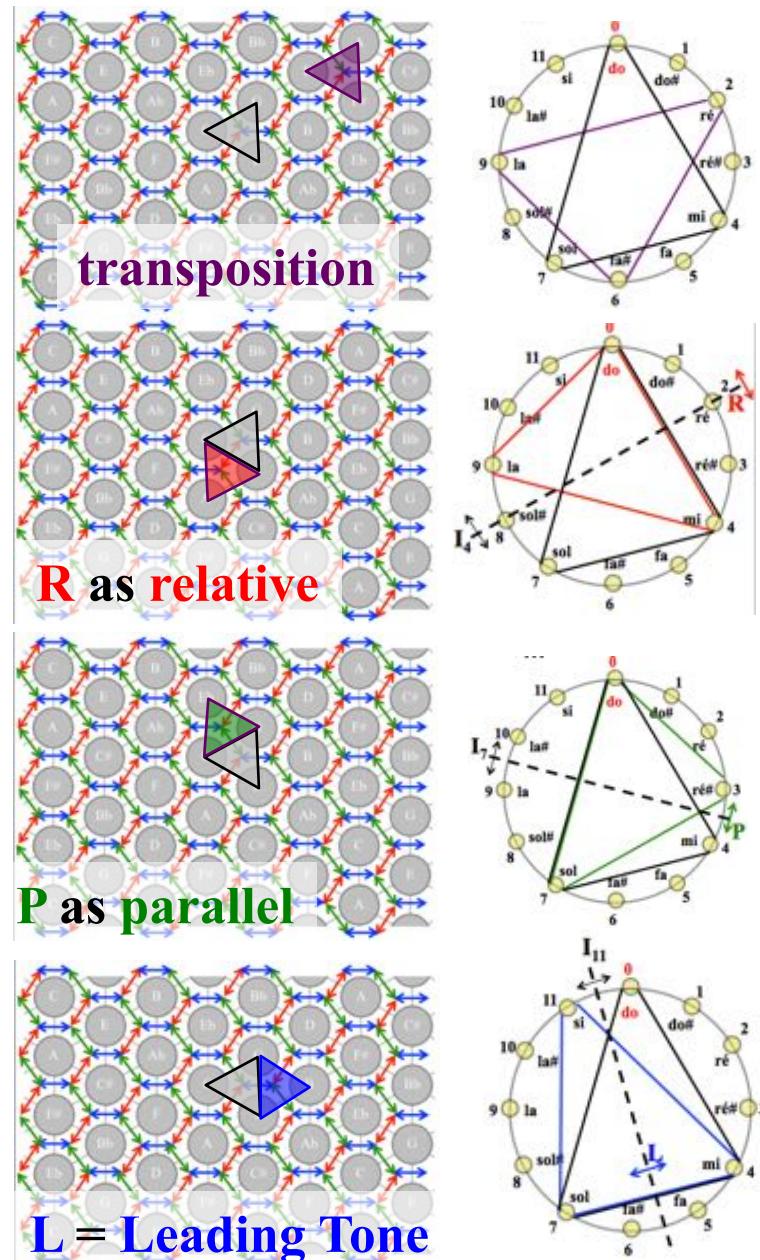
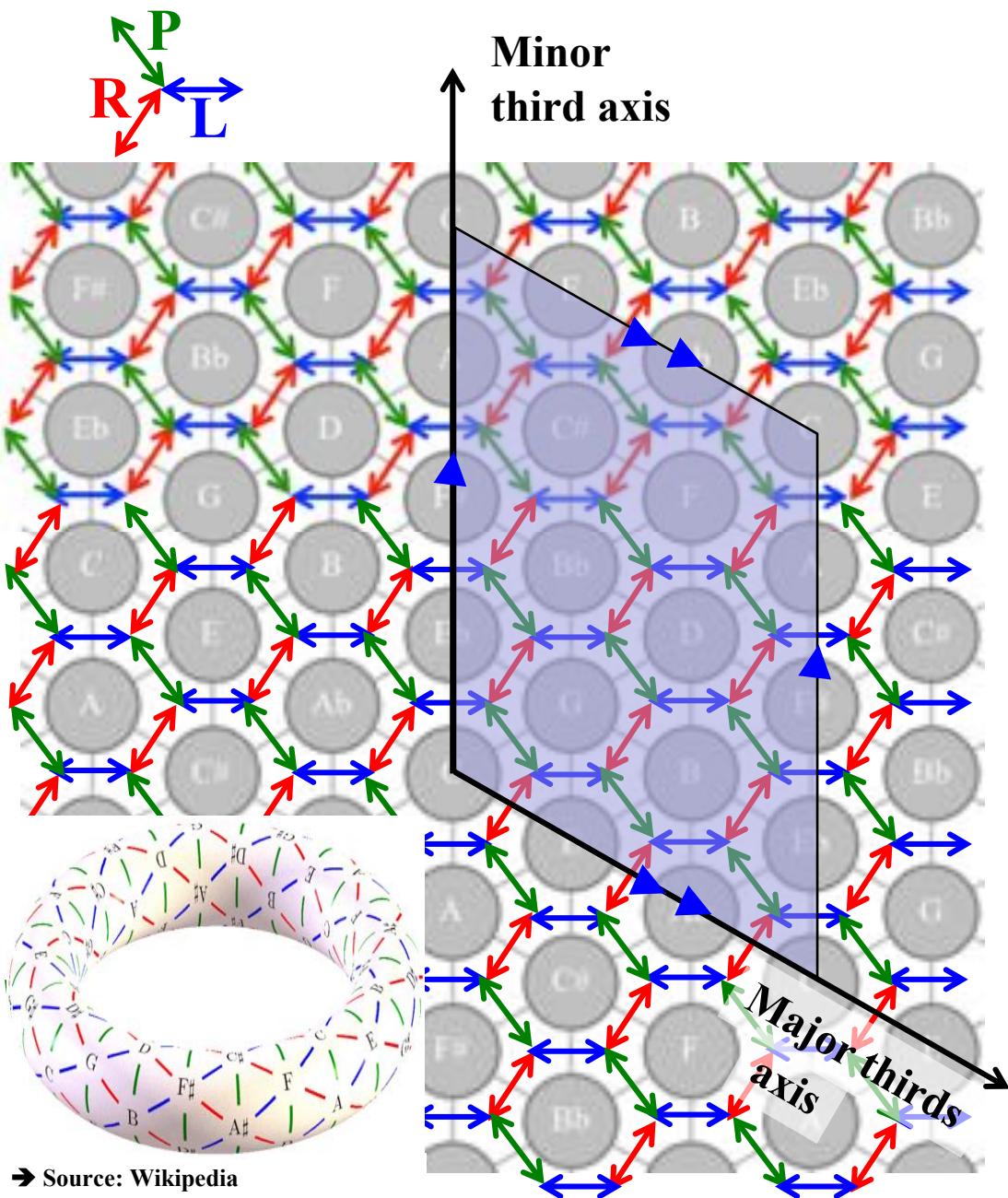
The Tonnetz, its symmetries and its topological structure



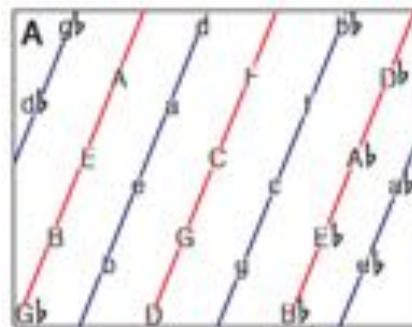
The Tonnetz, its symmetries and its topological structure



The Tonnetz, its symmetries and its topological structure



Tonnetz et neurosciences cognitives



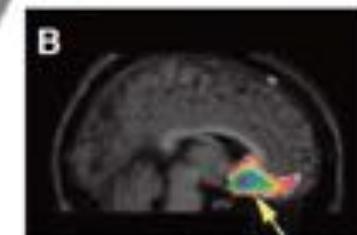
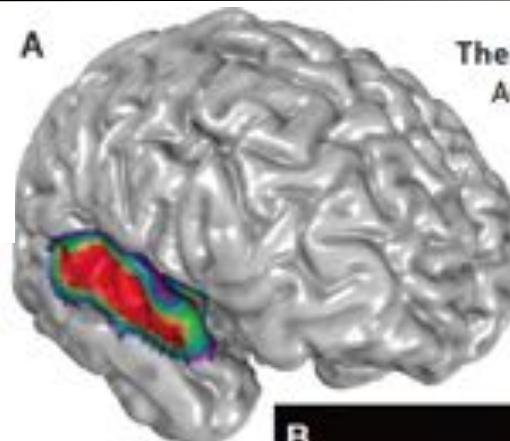
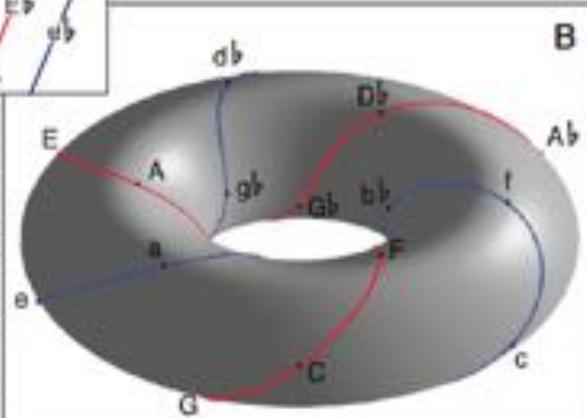
Mental key maps. (A) Unfolded version of the key map, with opposite edges to be considered matched. There is one circle of fifths for major keys (red) and one for minor keys (blue), each

wrapping the torus three times. In this way, every major key is flanked by its relative minor on one side (for example, C major and a minor) and its parallel minor on the other (for example, C major and c minor). (B) Musical keys as points on the surface of a torus.

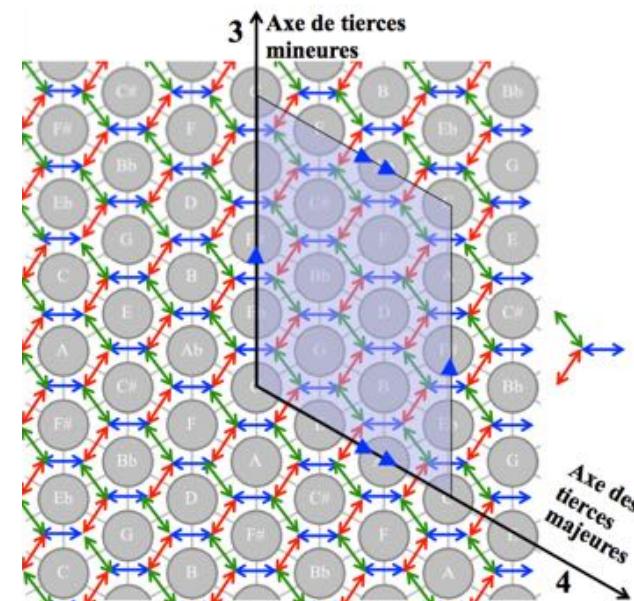
PERSPECTIVES: NEUROSCIENCE

Mental Models and Musical Minds

Robert J. Zatorre and Carol L. Krumhansl



The sensation of music. (A) Auditory cortical areas in the superior temporal gyrus that respond to musical stimuli. Regions that are most strongly activated are shown in red. (B) Metabolic activity in the ventromedial region of the frontal lobe increases as a tonal stimulus becomes more consonant.



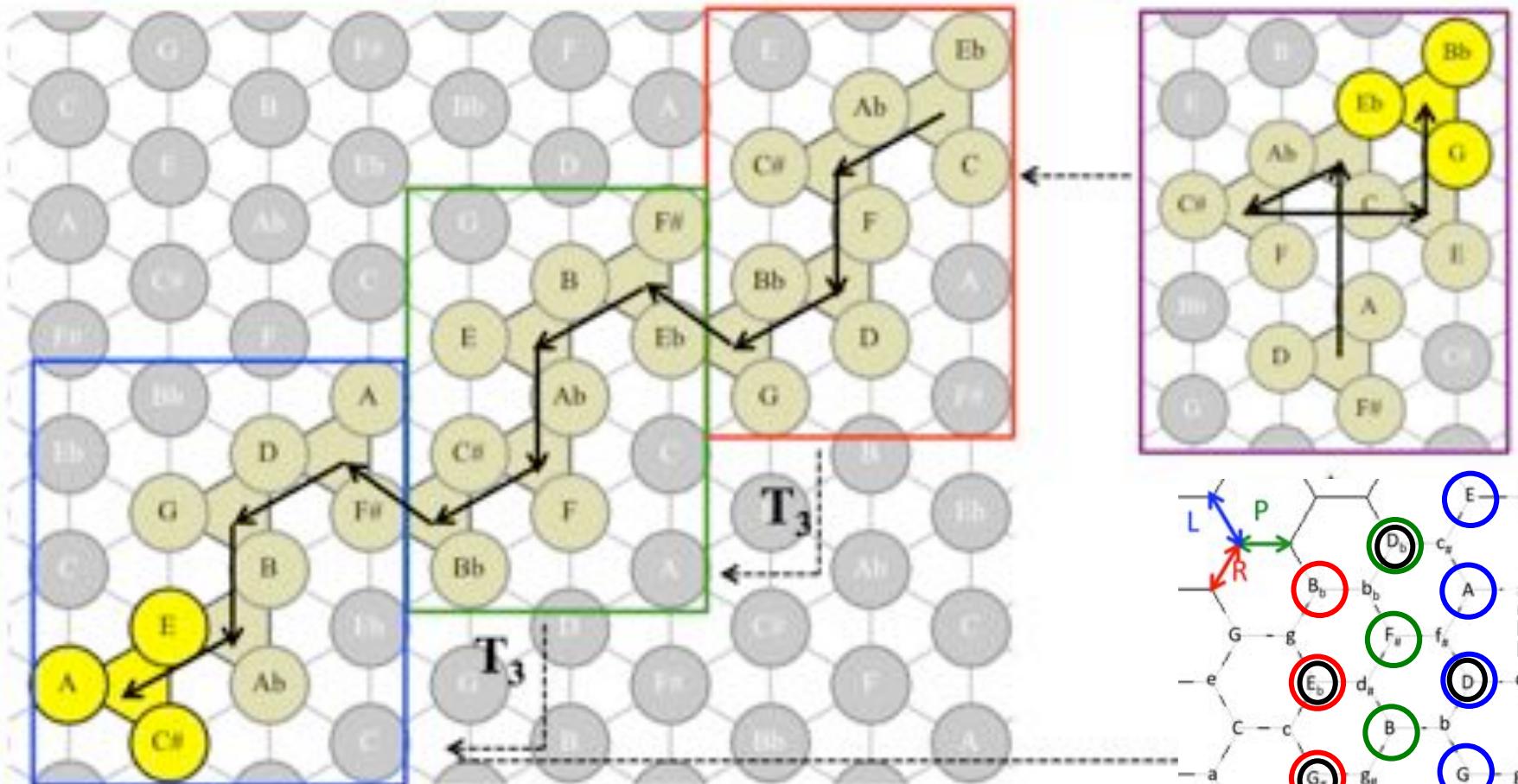
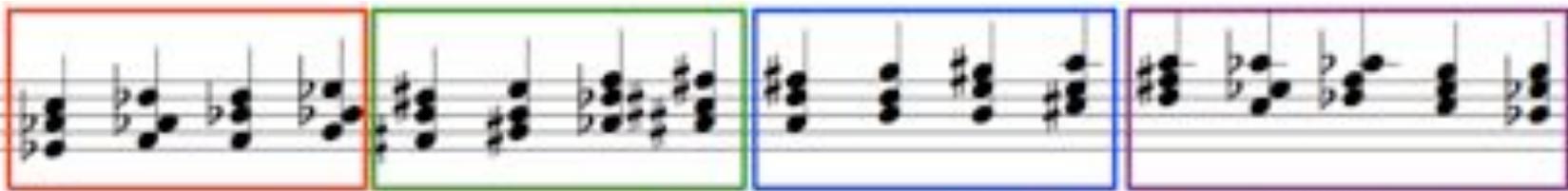
Acotto E. et M. Andreatta (2012),
« Between Mind and Mathematics.
Different Kinds of Computational
Representations of Music »,
Mathematics and Social Sciences, n°
199, 2012(3), p. 9-26.



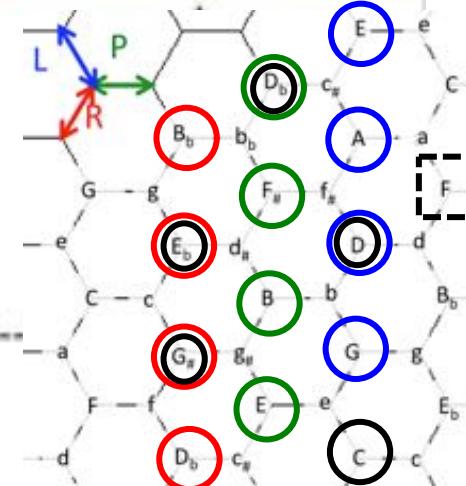


Symmetries in Paolo Conte's *Madeleine*

La_b Re_b Si_b Mi_b Si Mi Re_b Fa_# Re Sol Mi La Re La_b Re_b Do Mi_b



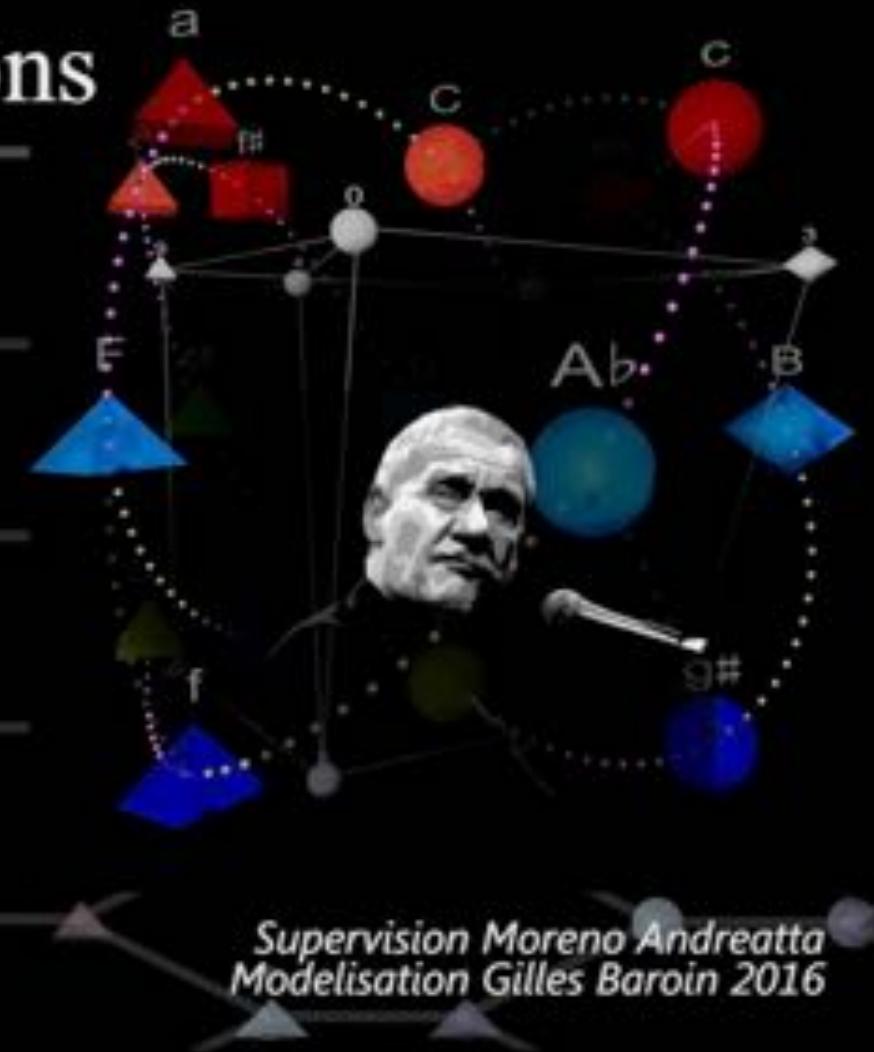
Almost total covering of the major-chords space



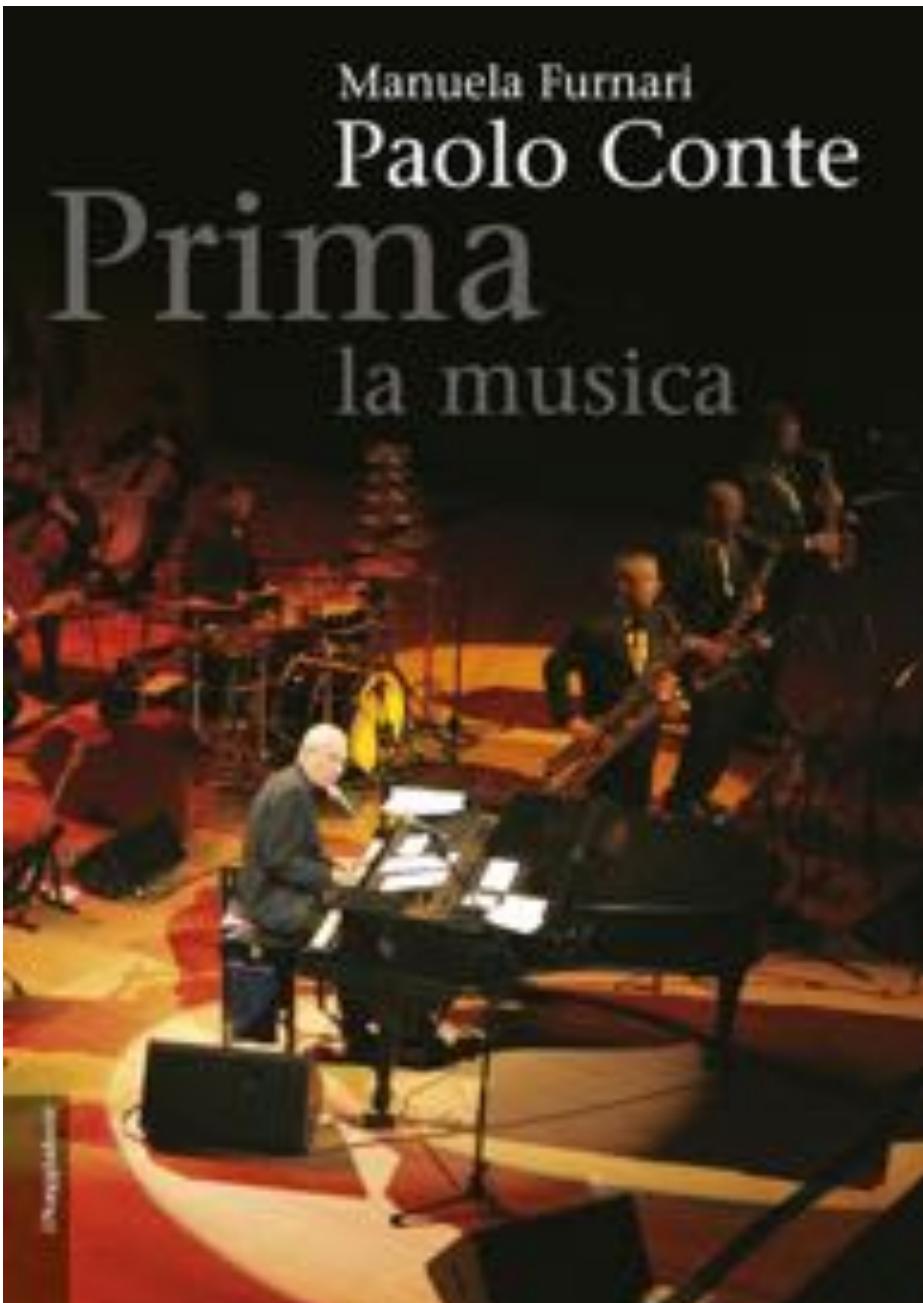
Harmonic Progressions

In Paolo Conte

Madeleine



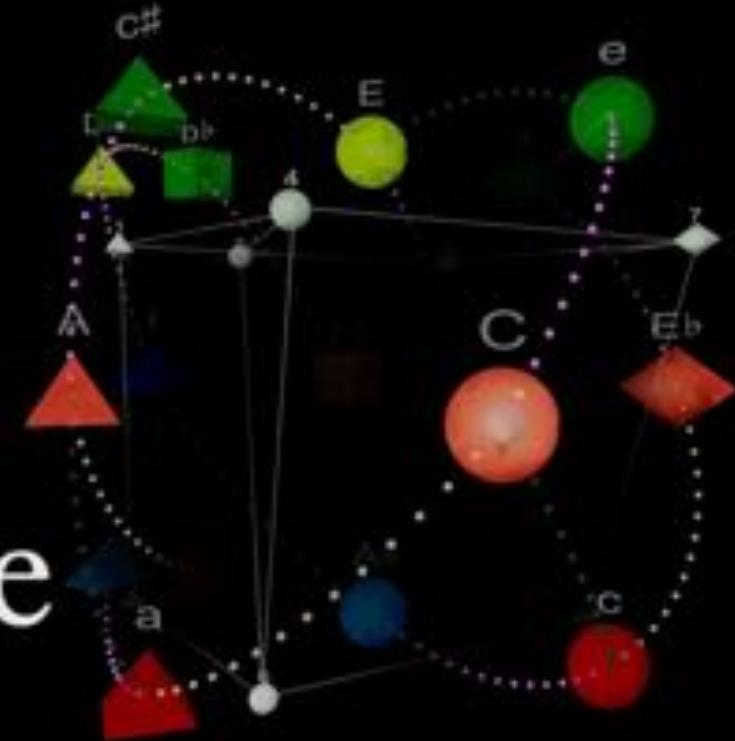
The place of harmonic structures in Paolo Conte's music



Scrivere prima la musica e poi il testo mi obbliga ad un procedimento preso in prestito dal cinema. **Una canzone** è forse più cinema che poesia o musica: **è il sogno di qualcosa che vorrebbe muoversi.** La **camminata orizzontale dell'armonia.**

L'abilità nel muoversi armonicamente e enarmonicamente appartiene a tutta la musica. Uno dei limiti del jazz è quello di insistere sempre sullo stesso giro armonico. Io penso che l'**orecchio** dopo un po' [...] **abbia bisogno di spostarsi** [...] da questa continua attenzione sulla **stessa tonalità.**

Beethoven and the Hypersphere *(and the Tonnetz)*



Gilles Baroin 2016
www.MatheMusic.net

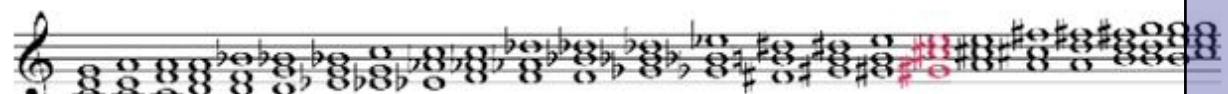
Reading Beethoven backwards

Le Blé en Herbe

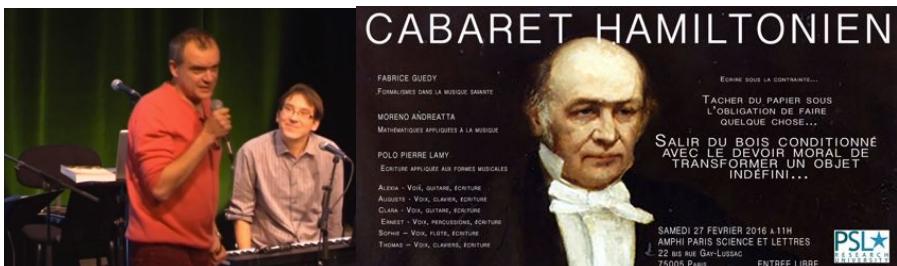
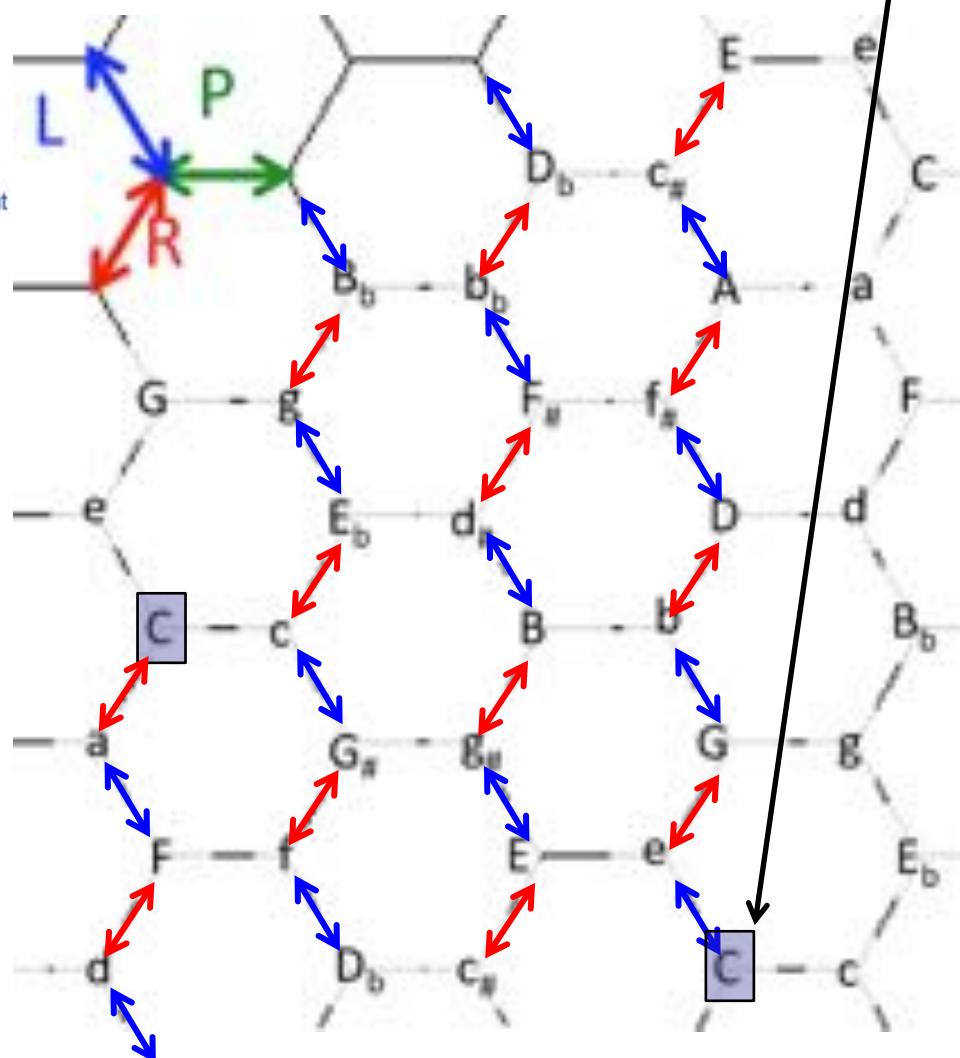


(Polo/Moreno/Dieu)

- | | |
|--|--|
| Plonger comme un enfant, cheveux au vent | Croiser matin dans l'herbe folle |
| Sous l'océan du blé en herbe | Deux tourterelles qui s'envolent |
| Marée d'épis couleur d'amande | Suivre les jeux des hirondelles |
| Qui tendent à caresser le ciel | Sur le paysage éternel |
| Algues tendres de mille plages | Nager comme un enfant, cheveux au vent |
| Frôlant le ventre des nuages | Sous l'océan |
| Cheveux de pluie, dos de poissons | Du blé en herbe |
| Qui frissonnent à l'unisson | Marée de fruits au goût amer |
| Suivre le bord des continents | Acide et salée comme la mer |
| Dans l'océan du blé en herbe | Vers l'îlot d'un petit village |
| Pêcher le corail du pavot | Vers un château d'eau sur la plage |
| Dans le sang des coquelicots | Quand tout s'éteint avant l'orage |
| | Quand se lève le vent du large |
| | Sur le blé vert |



← time



CABARET HAMILTONIEN

FABRICE QUEDY
FONDATEUR DE LA MUSIQUE D'AMÉRIQUE
MORENO ANDREATA
MATHÉMATIQUES APPLIQUÉES À LA MUSIQUE
POLO PIERRE LAMY
ÉCRITURE APPLIQUÉE AUX FORMES MUSICIALES
ALEXIA - VOIX, GUITARE, CONTREBASSE
AUGUSTE - VOIX, CLAVIER, ÉCRITURE
CLARA - VOIX, GUITARE, ÉCRITURE
ERNEST - VOIX, PERCUSSIONS, FORTUNE
SOPHIE - VOIX, FLUTE, ÉCRITURE
THOMAS - VOIX, CLAVIERS, ÉCRITURE

ÉCRIRE SOUS LA CONTRAINTE...
TACHER DU PAPIER SOUS L'OBLIGATION DE FAIRE QUELQUE CHOSE...
SALIR DU BOIS CONDITIONNÉ AVEC LE DEVOIR MORAL DE TRANSFORMER UN OBJET INDEFINII...

SAMEDI 27 FEVRIER 2016 à 21h
AMPHI PARIS SCIENCE ET LETTRES
22 bis RUE GAY-LUSSAC
75005 PARIS
ENTREE LIBRE

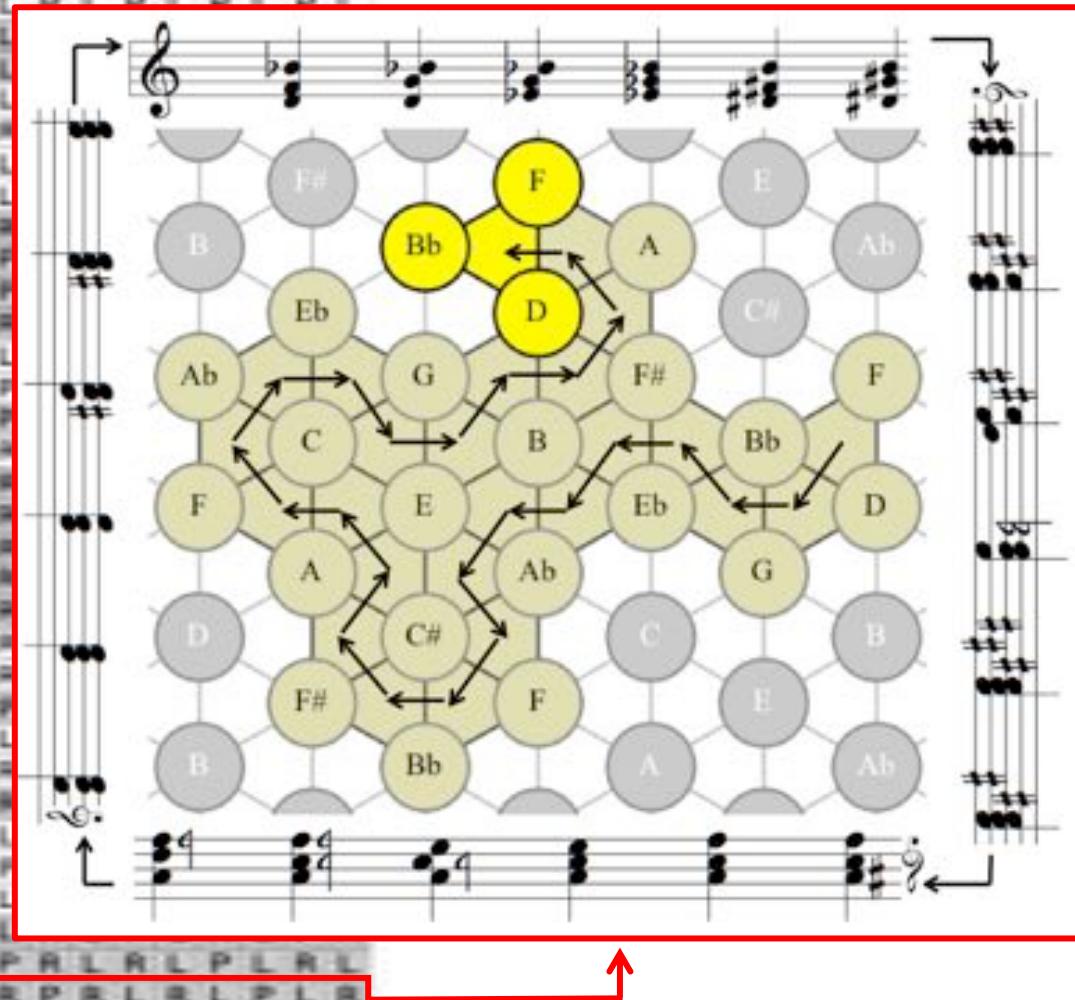
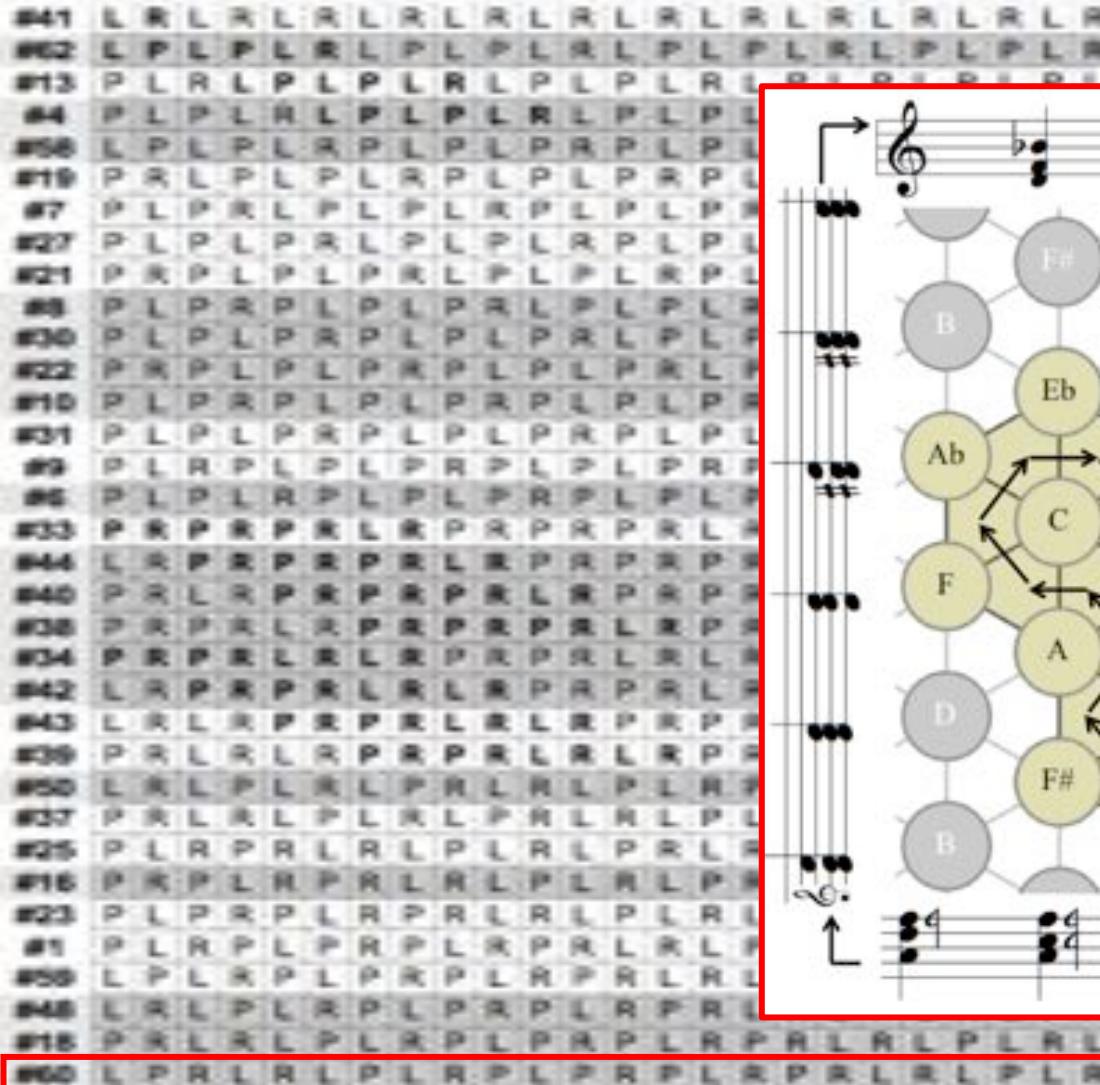
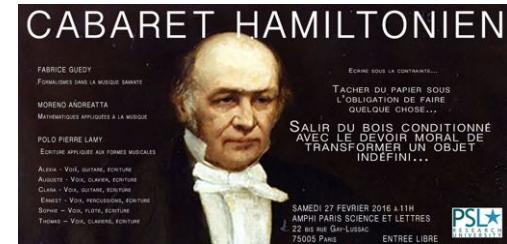


The collection of 124 Hamiltonian Cycles

ACTIONS

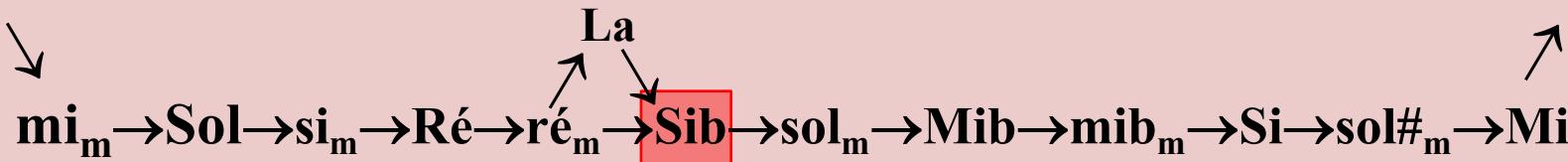
Math'n'pop

Aprile (d'après Gabriele D'Annunzio)



Aprile, a Hamiltonian « decadent » song

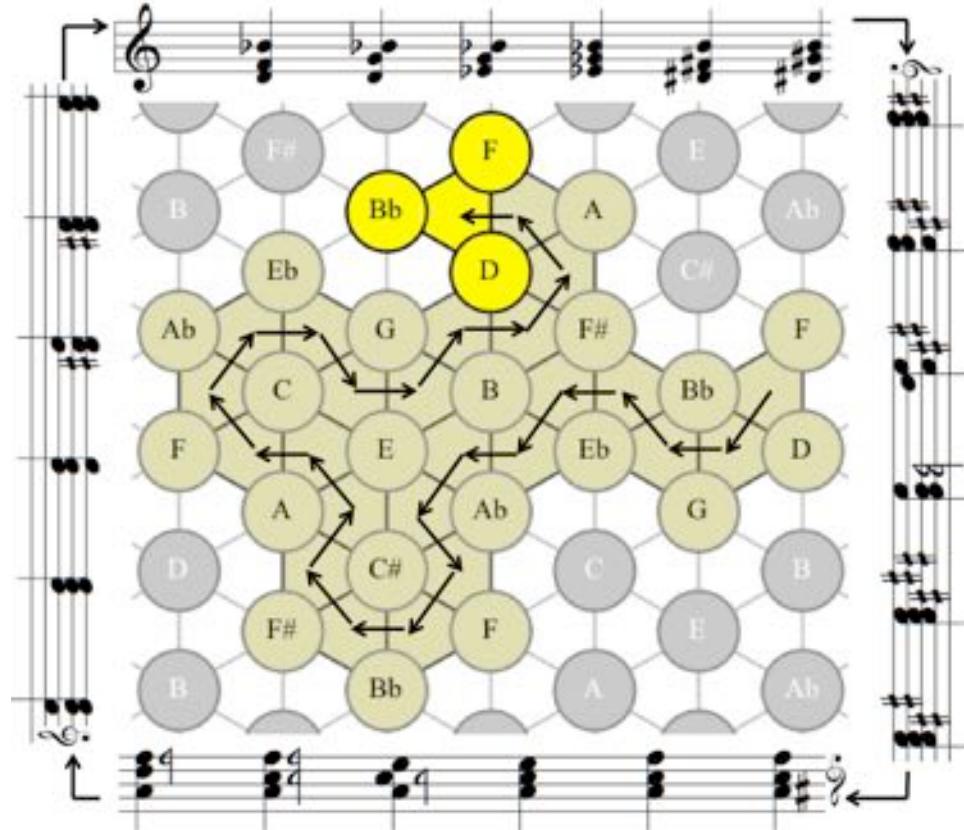
Do←**do_m**←**Sol#**←**fa_m**←**Fa**←**la_m**←**La**←**fa#_m**←**Fa#**←**sib_m**←**Do#**←**do#_m**



*Socchiusa è la finestra, sul giardino.
Un'ora passa lenta, sonnolenta.
Ed ella, ch'era attenta, s'addormenta
A quella voce che già si lamenta,
Che si lamenta in fondo a quel giardino.*

*Non è che voce d'acque su la pietra:
E quante volte, quante volte udita!
Quell'amore e quell'ora in quella vita
S'affondan come ne l'onda infinita
Stretti insieme il cadavere e la pietra.*

*Ella stende l'angoscia sua nel sonno.
L'angoscia è forte, e il sonno è così lieve!
(Par i' luce d'aprile quasi una neve
che sia tiepida.)
Ed ella certo deve soffrire,
Vagamente, anche nel sonno.*



ACTIONS

Math'n'pop

Aprile (d'après Gabriele D'Annunzio)

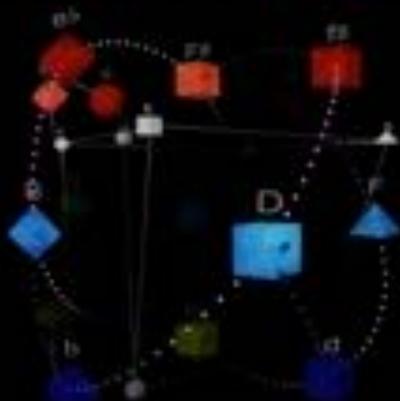
Aprile

Hamiltonian Song



G. D'Annunzio
(1863-1938)

Mathemusical
2D & 4D Visualizations



Composition, Performance: Moreno Andreatta

Hyperspheres & Animations: Gilles Baroin

Spinnen-Tonnetz: Hugo Seress & G.B

Lyrics by Gabriele D'Annuzio

www.MatheMusic.net

The collection of 28 « redundant » Hamiltonian Cycles

1. C-Cm-Ab-Abm-E-C#m-A-Am-F-Fm-C#-Bbm-F#-F#m-D-Dm-Bb-Gm-Eb-Ebm-B-Bm-G-Em--PLPLRL
2. C-Cm-Ab-Fm-C#-C#m-A-Am-F-Dm-Bb-Bbm-F#-F#m-D-Bm-G-Gm-Eb-Ebm-B-Abm-E-Em--PLRLPL
3. C-Cm-Eb-Ebm-F#-F#m-A-C#m-E-Em-G-Gm-Bb-Bbm-C#-Fm-Ab-Abm-B-Bm-D-Dm-F-Am--PRPRPRLR
4. C-Cm-Eb-Ebm-F#-Bbm-C#-C#m-E-Em-G-Gm-Bb-Dm-F-Fm-Ab-Abm-B-Bm-D-F#m-A-Am--PRPRLRPR
5. C-Cm-Eb-Ebm-F#-Bbm-C#-Fm-Ab-Abm-B-Bm-D-F#m-A-C#m-E-Em-G-Gm-Bb-Dm-F-Am--PRPRLRLR
6. C-Cm-Eb-Gm-Bb-Bbm-C#-C#m-E-Em-G-Bm-D-Dm-F-Fm-Ab-Abm-B-Ebm-F#-F#m-A-Am--PRLRPRPR
7. C-Cm-Eb-Gm-Bb-Bbm-C#-Fm-Ab-Abm-B-Ebm-F#-F#m-A-C#m-E-Em-G-Bm-D-Dm-F-Am--PRLRLR
8. C-Cm-Eb-Gm-Bb-Dm-F-Fm-Ab-Abm-B-Ebm-F#-Bbm-C#-C#m-E-Em-G-Bm-D-F#m-A-Am--PRLRLRPR
9. C-Em-E-Abm-Ab-Cm-Eb-Gm-G-Bm-B-Ebm-F#-Bbm-Bb-Dm-D-F#m-A-C#m-C#-Fm-F-Am--LPLPLR
10. C-Em-E-Abm-B-Ebm-Eb-Gm-G-Bm-D-F#m-F#-Bbm-Bb-Dm-F-Am-A-C#m-C#-Fm-Ab-Cm--LPLRLP
11. C-Em-G-Gm-Bb-Bbm-C#-C#m-E-Abm-B-Bm-D-Dm-F-Fm-Ab-Cm-Eb-Ebm-F#-F#m-A-Am--LRPRPRPR
12. C-Em-G-Gm-Bb-Bbm-C#-Fm-Ab-Cm-Eb-Ebm-F#-F#m-A-C#m-E-Abm-B-Bm-D-Dm-F-Am--LRPRPRLR
13. C-Em-G-Gm-Bb-Dm-F-Fm-Ab-Cm-Eb-Ebm-F#-Bbm-C#-C#m-E-Abm-B-Bm-D-F#m-A-Am--LRPR
14. C-Em-G-Bm-B-Ebm-Eb-Gm-Bb-Dm-D-F#m-F#-Bbm-C#-Fm-F-Am-A-C#m-E-Abm-Ab-Cm--LRLPLP
15. C-Em-G-Bm-D-Dm-F-Fm-Ab-Cm-Eb-Gm-Bb-Bbm-C#-C#m-E-Abm-B-Ebm-F#-F#m-A-Am--LRLRPRPR
16. C-Em-G-Bm-D-F#m-A-C#m-E-Abm-B-Ebm-F#-Bbm-C#-Fm-Ab-Cm-Eb-Gm-Bb-Dm-F-Am--LR
17. C-Am-A-F#m-F#-Ebm-Eb-Cm-Ab-Fm-F-Dm-D-Bm-B-Abm-E-C#m-C#-Bbm-Bb-Gm-G-Em--RPRPRPRL
18. C-Am-A-F#m-F#-Ebm-B-Abm-Ab-Fm-F-Dm-D-Bm-G-Em-E-C#m-C#-Bbm-Bb-Gm-Eb-Cm--RPRPLRP
19. C-Am-A-F#m-F#-Ebm-B-Abm-E-C#m-C#-Bbm-Bb-Gm-Eb-Cm-Ab-Fm-F-Dm-D-Bm-G-Em--RPRPRLRL
20. C-Am-A-F#m-D-Bm-B-Abm-Ab-Fm-F-Dm-Bb-Gm-G-Em-E-C#m-C#-Bbm-F#-Ebm-Eb-Cm--RPRLRPRP
21. C-Am-A-F#m-D-Bm-B-Abm-E-C#m-C#-Bbm-F#-Ebm-Eb-Cm-Ab-Fm-F-Dm-Bb-Gm-G-Em--RPRPL
22. C-Am-A-F#m-D-Bm-G-Em-E-C#m-C#-Bbm-F#-Ebm-B-Abm-Ab-Fm-F-Dm-Bb-Gm-Eb-Cm--RPRLRLRP
23. C-Am-F-Fm-C#-C#m-A-F#m-D-Dm-Bb-Bbm-F#-Ebm-B-Bm-G-Gm-Eb-Cm-Ab-Abm-E-Em--RLPLPL
24. C-Am-F-Dm-D-Bm-B-Abm-Ab-Fm-C#-Bbm-Bb-Gm-G-Em-E-C#m-A-F#m-F#-Ebm-Eb-Cm--RLRPRPRP
25. C-Am-F-Dm-D-Bm-B-Abm-E-C#m-A-F#m-F#-Ebm-Eb-Cm-Ab-Fm-C#-Bbm-Bb-Gm-G-Em--RLRPRPRL
26. C-Am-F-Dm-D-Bm-G-Em-E-C#m-A-F#m-F#-Ebm-B-Abm-Ab-Fm-C#-Bbm-Bb-Gm-Eb-Cm--RLRP
27. C-Am-F-Dm-Bb-Gm-G-Em-E-C#m-A-F#m-D-Bm-B-Abm-Ab-Fm-C#-Bbm-F#-Ebm-Eb-Cm--RLRLRPRP
28. C-Am-F-Dm-Bb-Gm-Eb-Cm-Ab-Fm-C#-Bbm-F#-Ebm-B-Abm-E-C#m-A-F#m-D-Bm-G-Em--RL



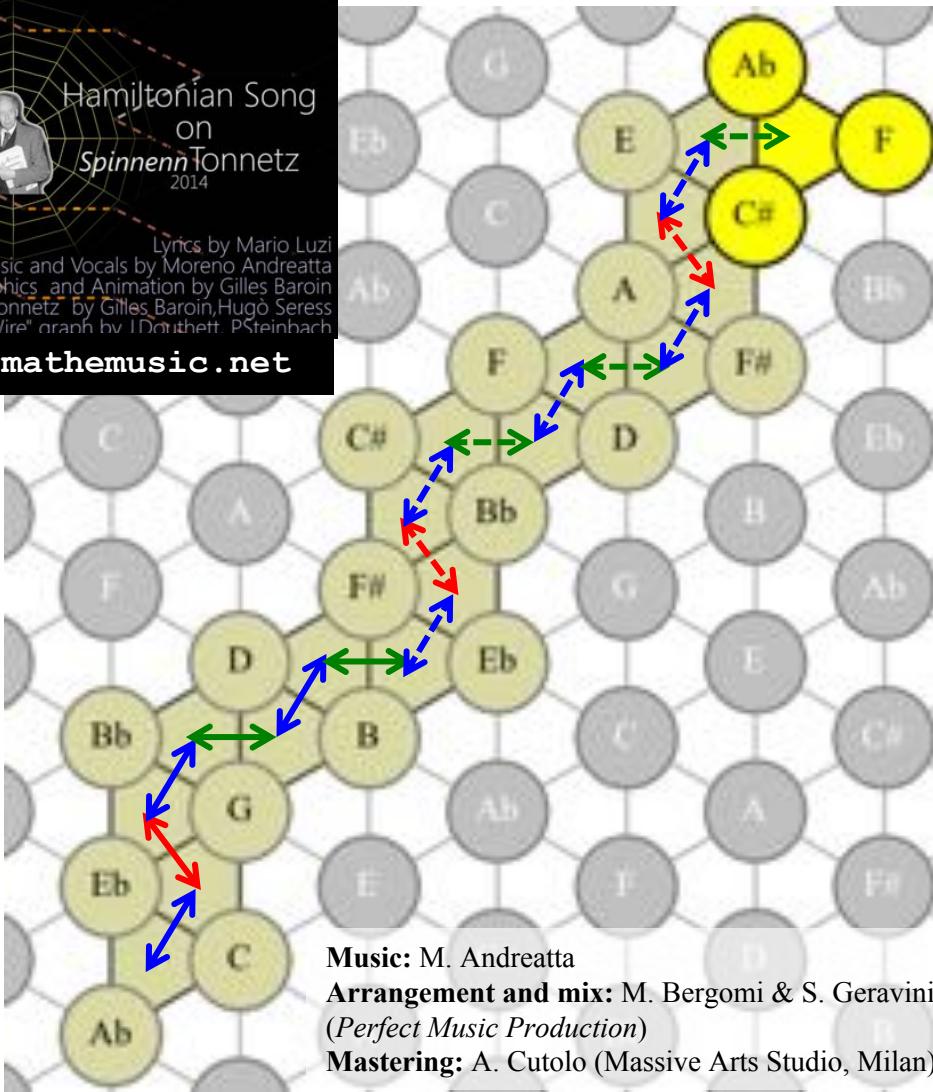
Hamiltonian Cycles with inner periodicities

8. C-Cm-Eb-Gm-Bb-Dm-F-Fm-Ab-Abm-B-Ebm-F#-Bbm-C#-C#m-E-Em-G-Bm-D-F#m-A-Am--PRLRLRPR
9. C-Em-E-Abm-Ab-Cm-Eb-Gm-G-Bm-B-Ebm-F#-Bbm-Bb-Dm-D-F#m-A-C#m-C#-Fm-F-Am--LPLPLR
10. C-Em-E-Abm-B-Ebm-Eb-Gm-G-Bm-D-F#m-F-Bbm-Bb-Dm-F-Am-A-C#m-C#-Fm-Ab-Cm--LPLRLP
11. C-Em-G-Gm-Bb-Bbm-C#-C#m-E-Abm-B-Bm-D-Dm-F-Fm-Ab-Cm-Eb-Ebm-F#-F#m-A-Am--LRPRPRPR
12. C-Em-G-Gm-Bb-Bbm-C#-Fm-Ab-Cm-Eb-Ebm-F#-F#m-A-C#m-E-Abm-B-Bm-D-Dm-F-Am--LRPRPRLR



L P L P L R ...
 P L P L R L ...
 L P L R L P ...
 PL R L P L ...
L R L P L P ...
 R L P L P L ...

Luzi



La sera non è più la tua canzone
 (Mario Luzi, 1945, in *Poesie sparse*)

La sera non è più la tua canzone,
 è questa roccia d'ombra traforata
 dai lumi e dalle voci senza fine,
 la quiete d'una cosa già pensata.

Ah questa luce viva e chiara viene
 solo da te, sei tu così vicina
 al vero d'una cosa conosciuta,
 per nome hai una parola ch'è passata
 nell'intimo del cuore e s'è perduta.

Caduto è più che un segno della vita,
 riposi, dal viaggio sei tornata
 dentro di te, sei scesa in questa pura
 sostanza così tua, così romita
 nel silenzio dell'essere, (compiuta).

L'aria tace ed il tempo dietro a te
 si leva come un'arida montagna
 dove vaga il tuo spirito e si perde,
 un vento raro scivola e ristagna.



Luzi



Hamiltonian Song
on
SpinnenTonnetz
2014

Lyrics by Mario Luzi

Music and Vocals by Moreno Andreatta

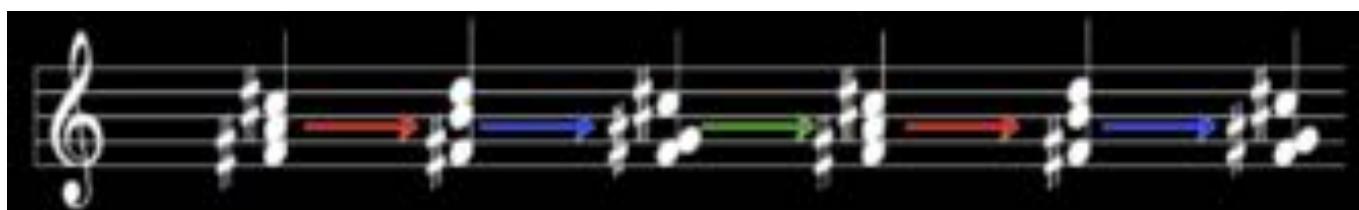
Graphics and Animation by Gilles Baroin

SpinnenTonnetz by Gilles Baroin, Hugo Seress

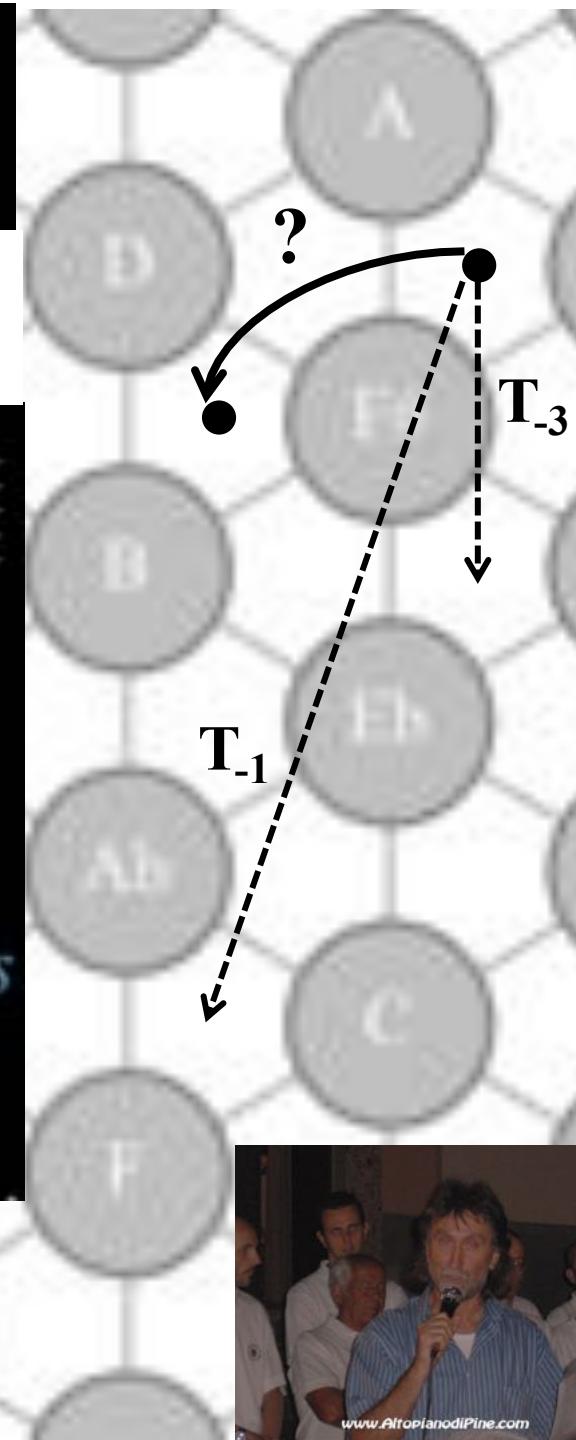
Original "Chicken Wire" graph by J.Douthett, P.Steinbach

DOMENEDIO

(‘canzone aperta’, based on a poetry by Livio Andreatta)



*Find all Hamiltonian Mathemusical Paths
that modulate through all minor triads
from f# min to b min, using only -1 or -3*



T[1,3,4]



4

3



↑
1

Notation:

C = Do minor

C# = Do# minor

.

.

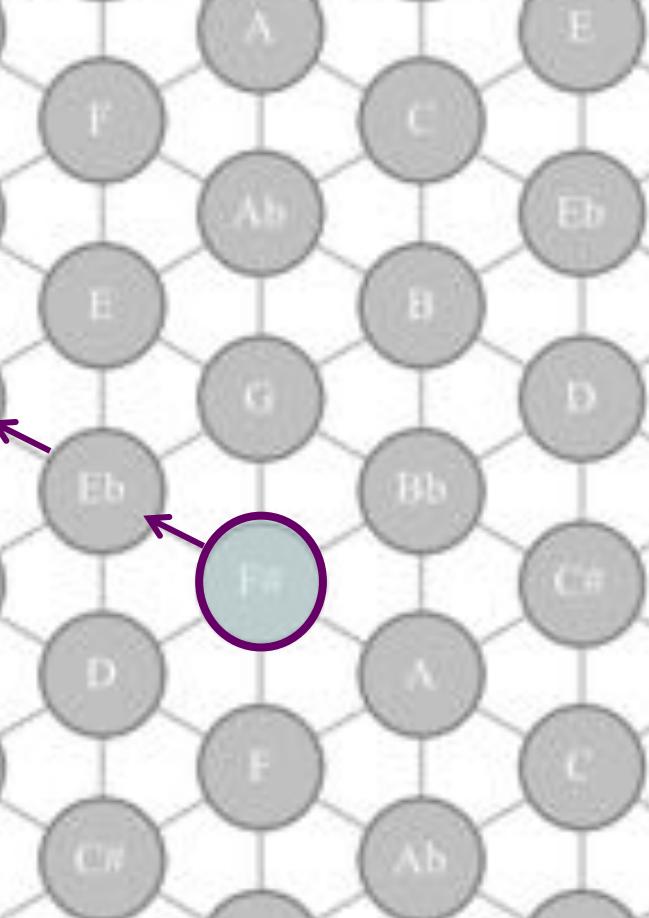
.

B = Si minor

DOMENEDIO



*Find all Hamiltonian Mathematical Paths
that modulate through all minor triads
from f# min to b min, using only -1 or -3*

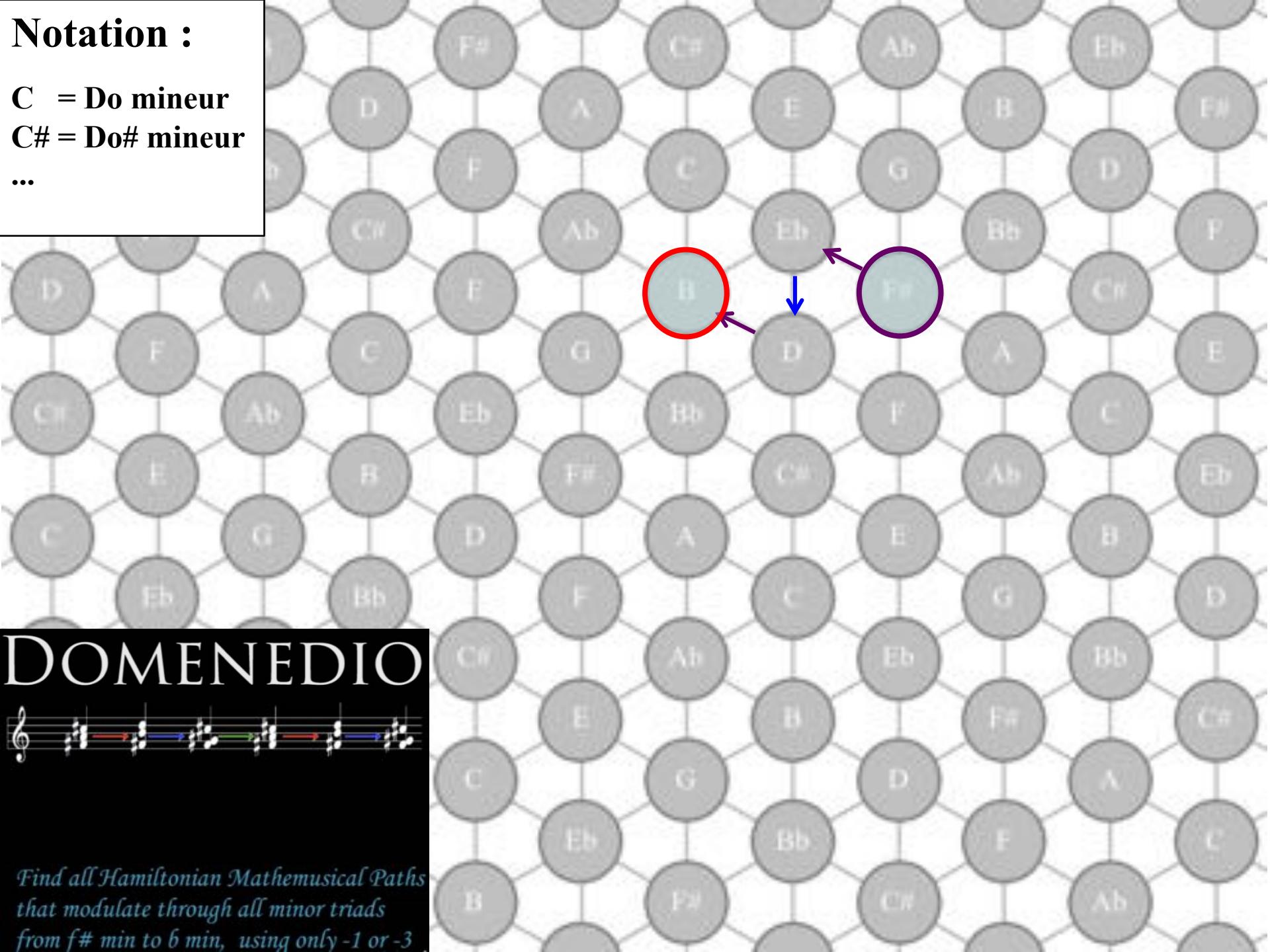


Notation :

C = Do mineur

C# = Do# mineur

...



DOMENEDIO



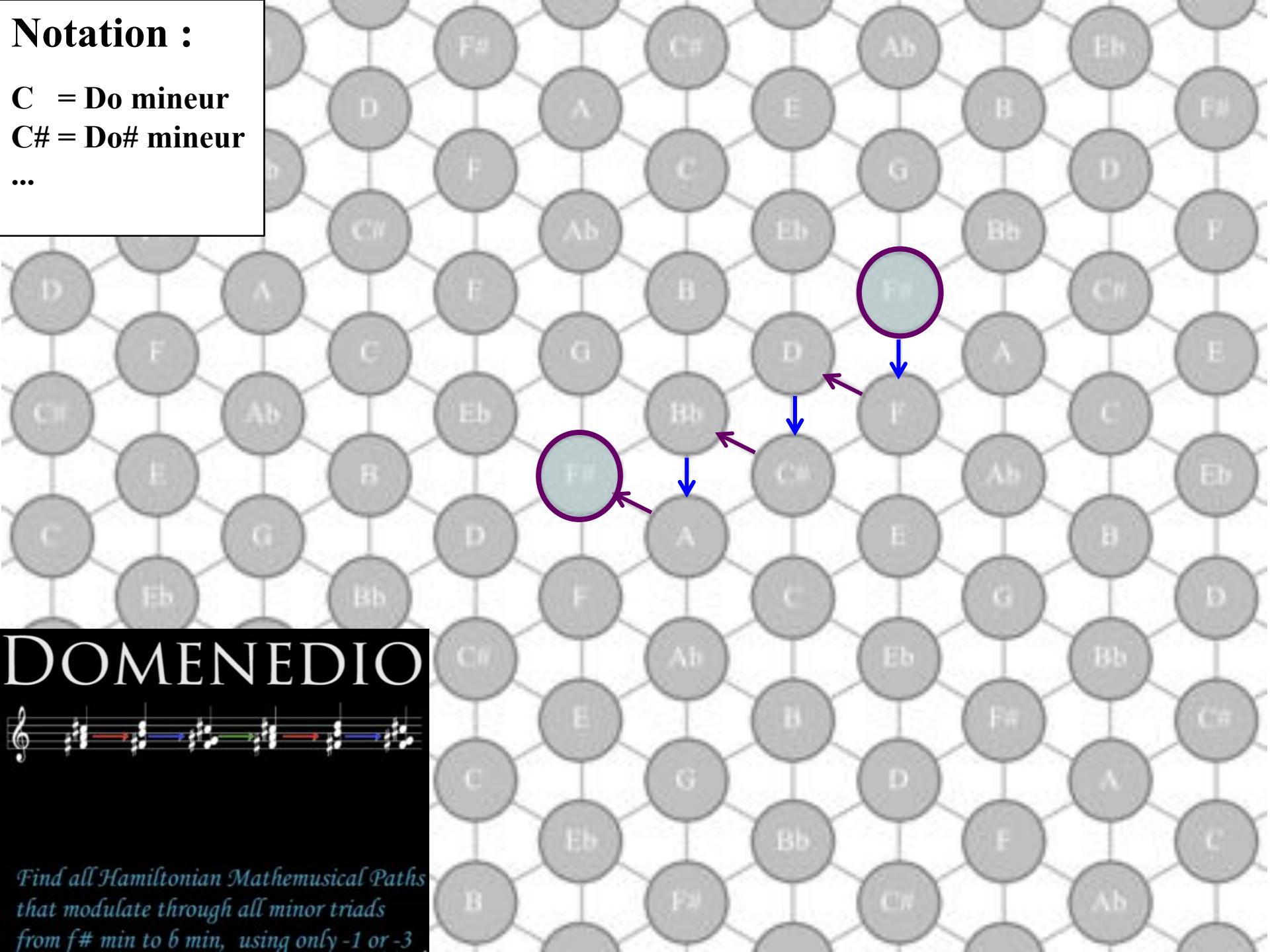
*Find all Hamiltonian Mathemusical Paths
that modulate through all minor triads
from f# min to b min, using only -1 or -3*

Notation :

C = Do mineur

C# = Do# mineur

...

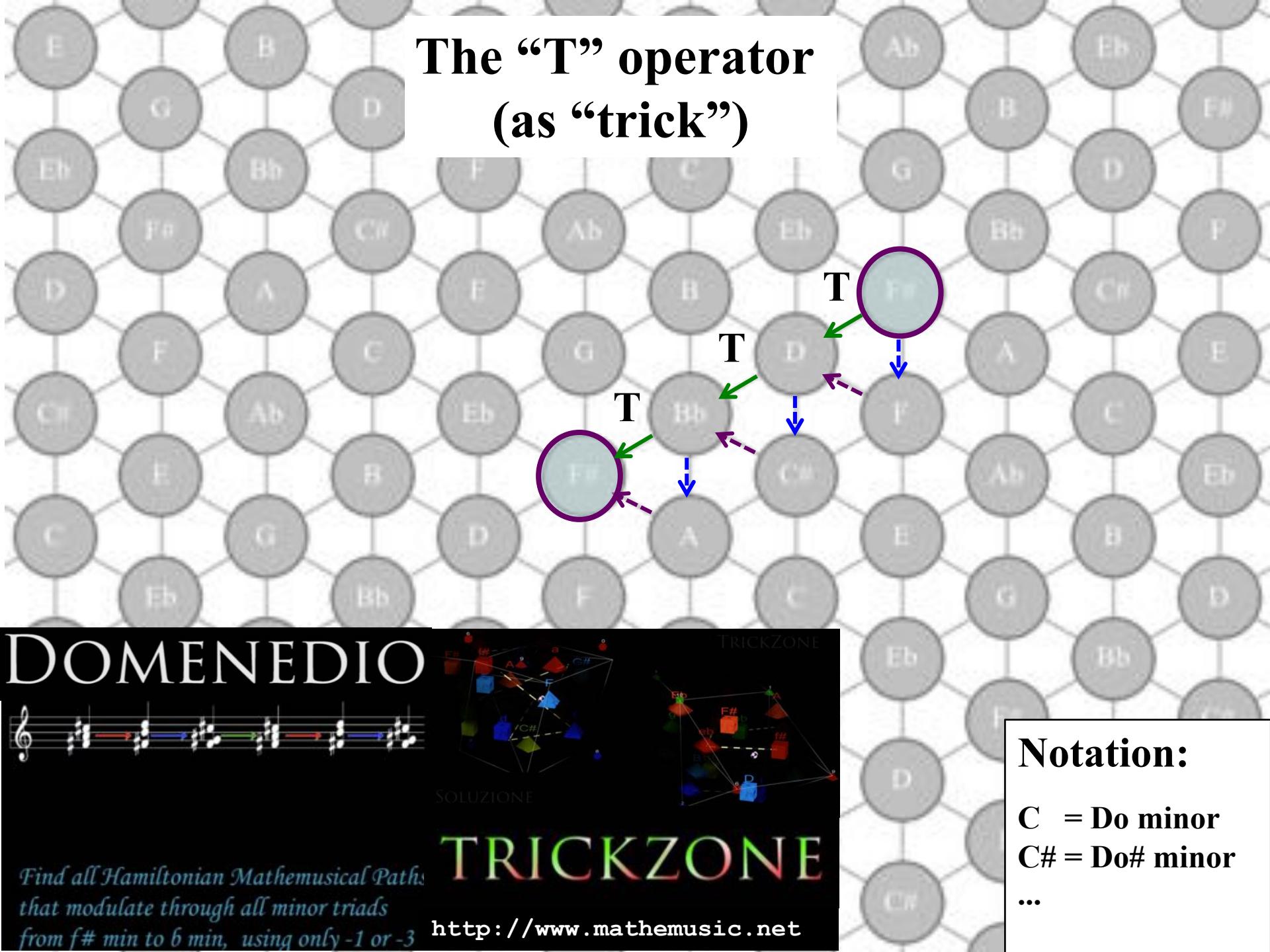


DOMENEDIO



*Find all Hamiltonian Mathemusical Paths
that modulate through all minor triads
from f# min to b min, using only -1 or -3*

The “T” operator (as “trick”)

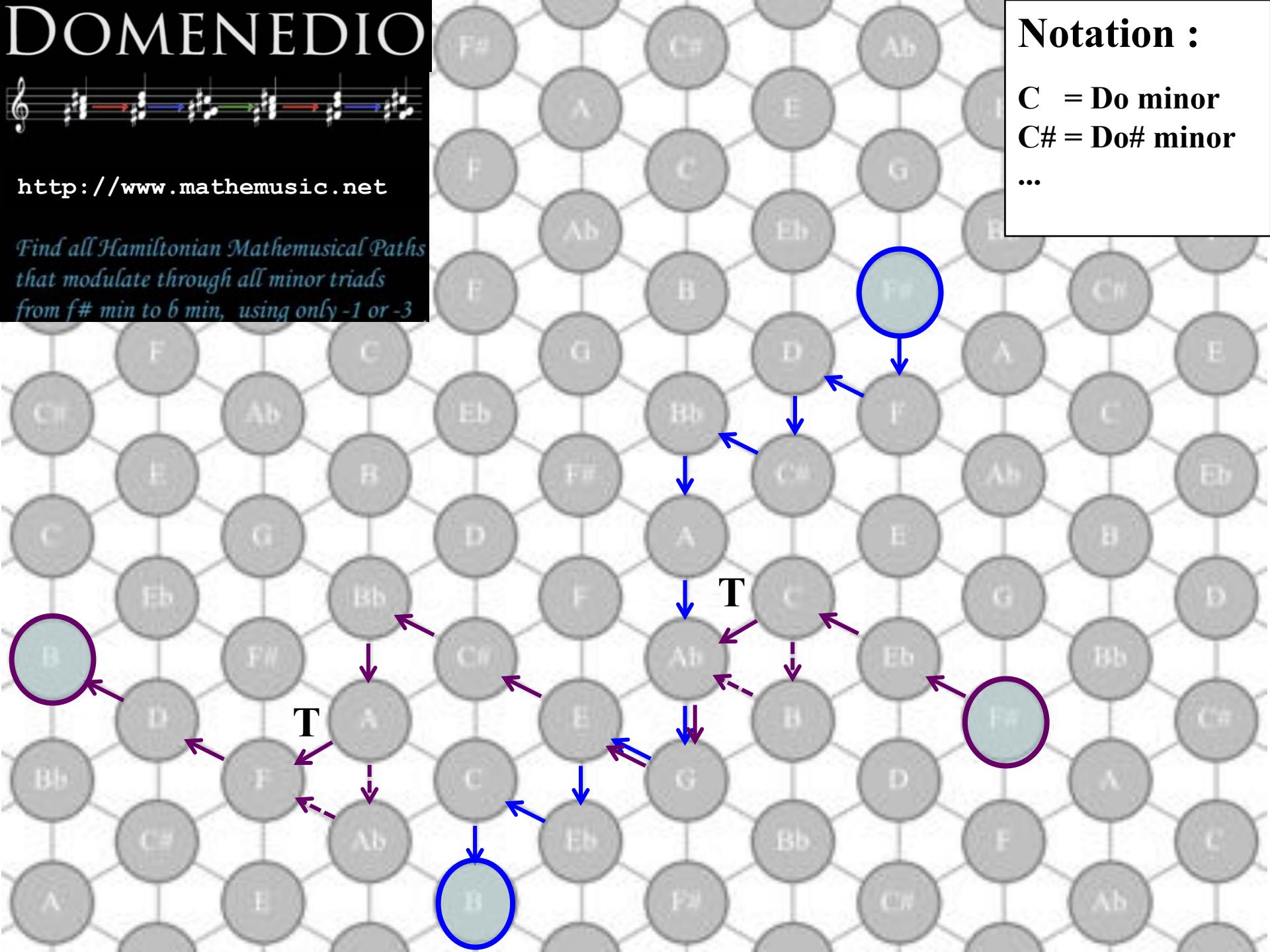


DOMENEDIO



<http://www.mathemusic.net>

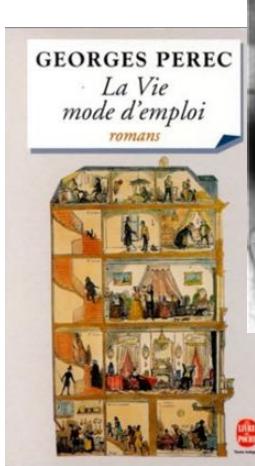
*Find all Hamiltonian Mathemusical Paths
that modulate through all minor triads
from f# min to b min, using only -1 or -3*



The use of constraints in arts



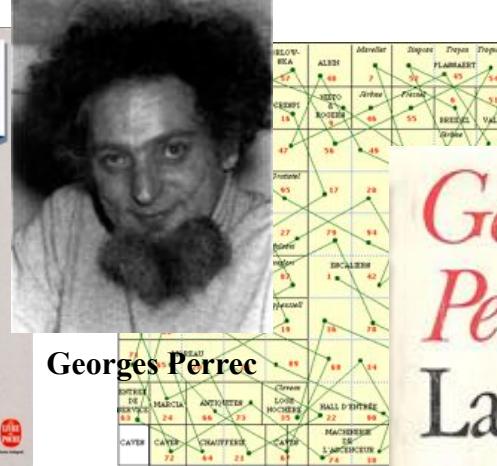
Cent mille milliards de poèmes, 1961



La vie mode d'emploi,



Georges Perec



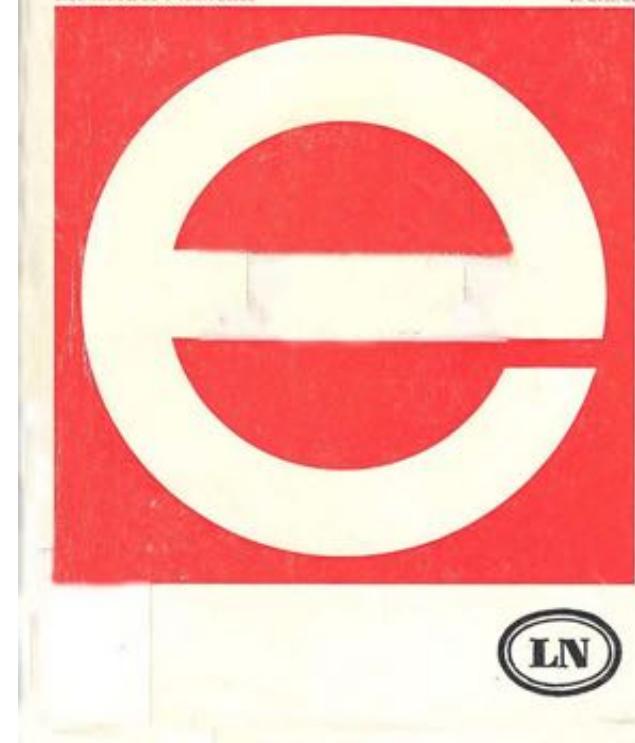
Georges
Perec

Roman

La disparition

Les Lettres Nouvelles

Denoël



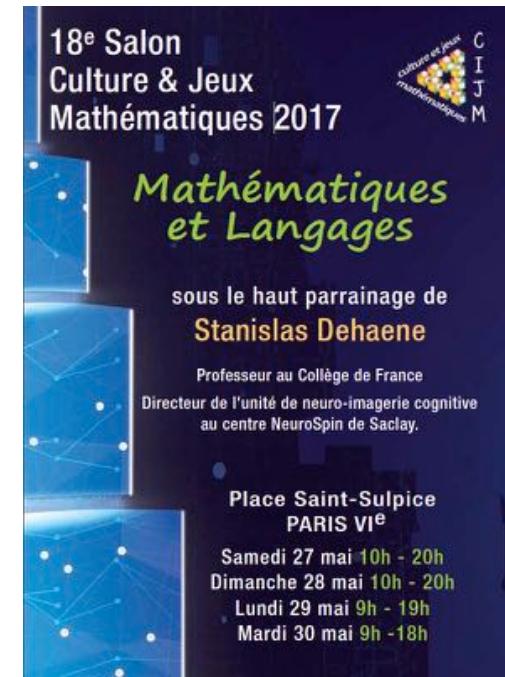
Raymond Queneau



Italo Calvino

*Il castello dei destini
incrociati*, 1969

From the OuLiPo to the OuMuPo (ouvroir de musique potentielle)



<http://oumupo.org/>



Valentin Villenave



Mike Solomon



Jean-François
Piette



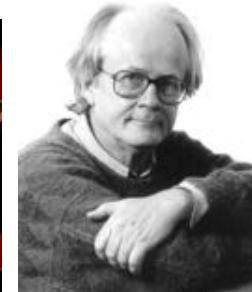
Martin
Granger



Joseph Boisseau

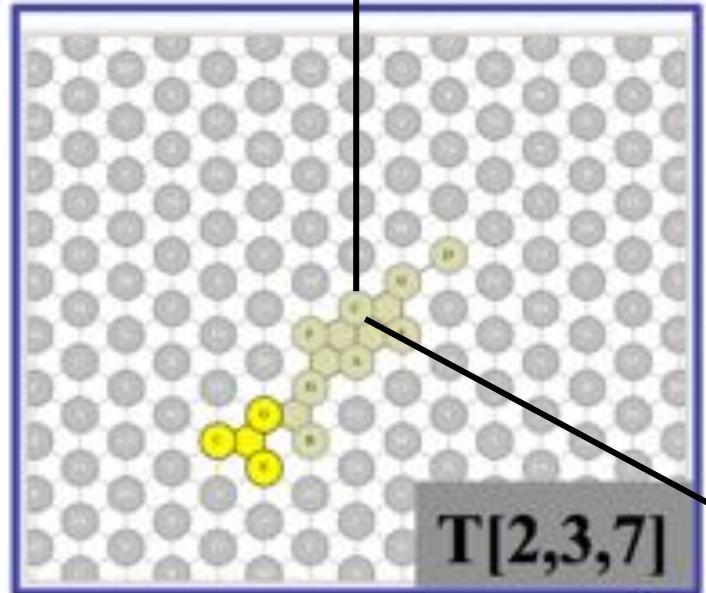
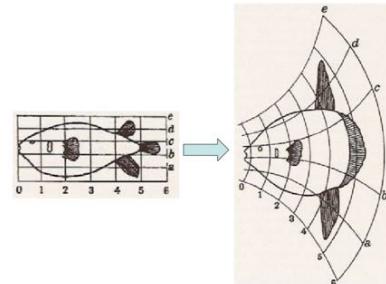
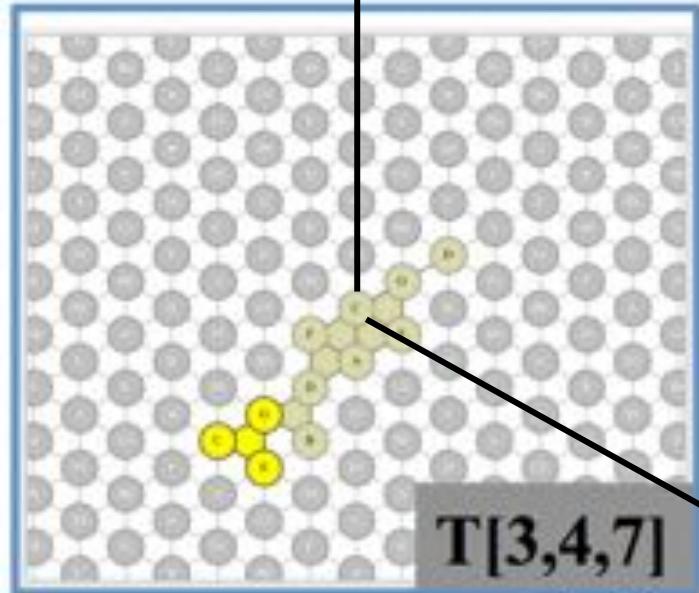


Moreno Andreatta

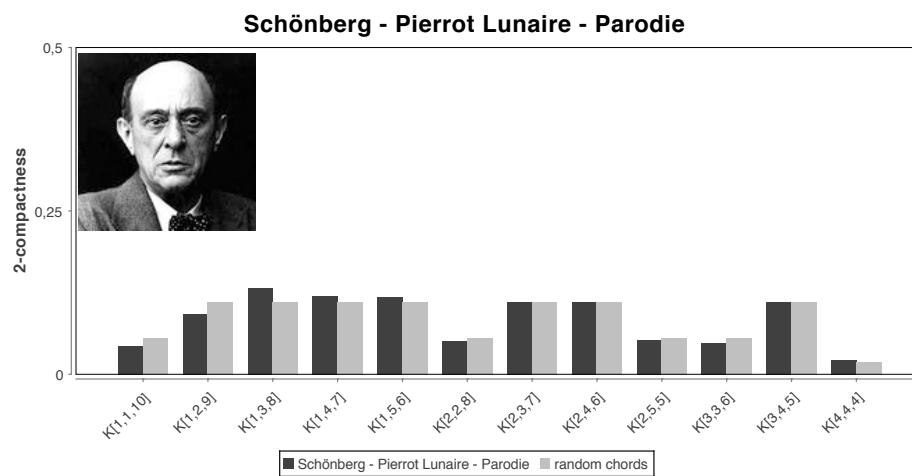
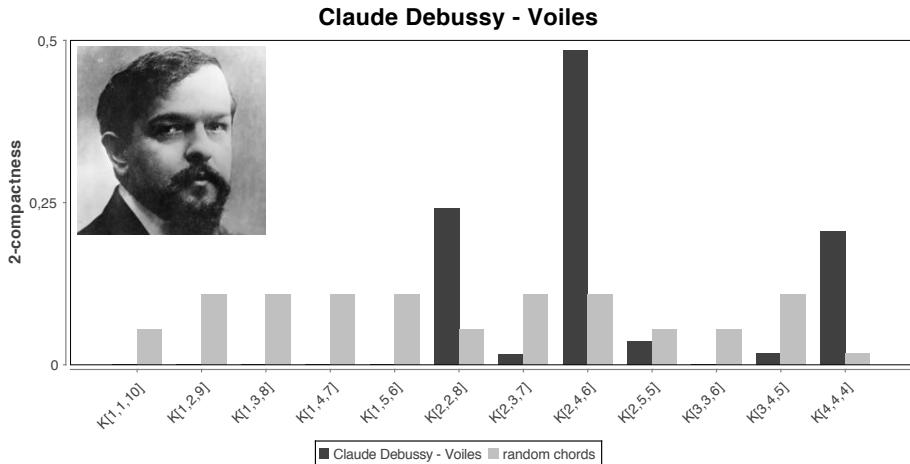
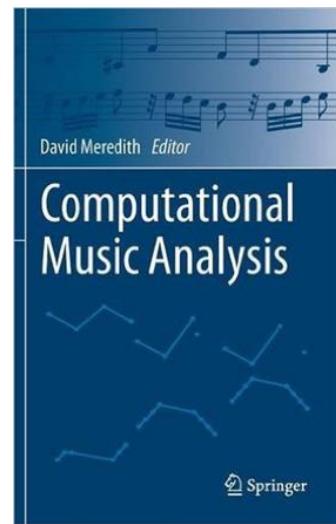
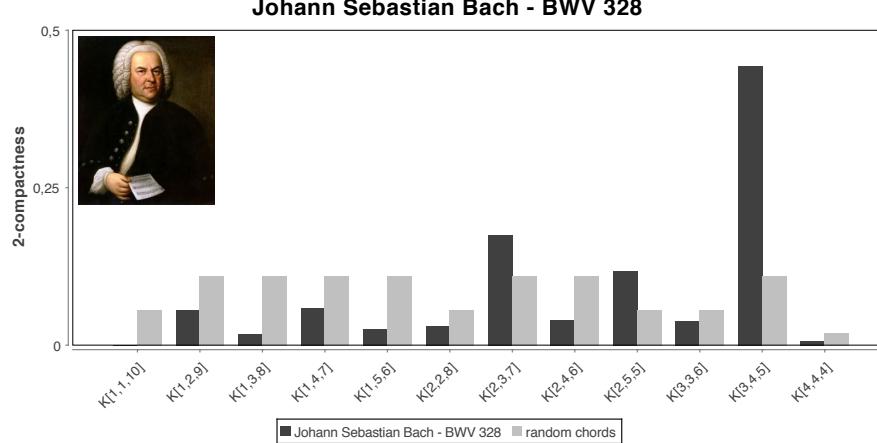
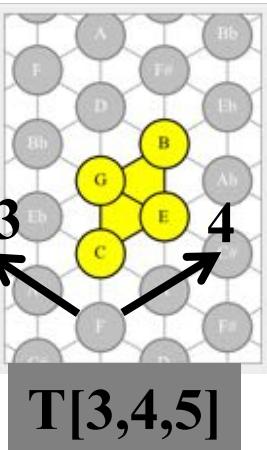
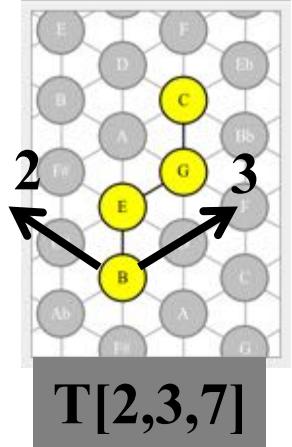


Tom Johnson

The musical style...is the space!



The geometric character of musical logic



Spatial music analysis via *Hexachord*

The image shows a composite screenshot of the Hexachord software interface and a copy of the 'Computer Music Journal'.

Hexachord Software Components:

- Hex Viewer:** A 3D visualization of a geometric polyhedron, likely representing a complex or set class.
- Tessellation:** A hexagonal grid representation of musical data, with specific hexagons highlighted in yellow and labeled with letters (A through H).
- InfoBox:** A control panel for a MIDI file named "bwv0281.mid". It includes:
 - Tempo slider (set to 10).
 - Play and Stop buttons.
 - Select midi file input field.
 - Chromatic complexes and Heptatonic complexes dropdown menus (both set to CM).
 - Trace off and Harmonization ON buttons.
 - Display graph button.
 - Vertical compactness section with compactness dimension (2), 2-compactness, compute compactness, and absolute compactness buttons.
 - Path Transformation section with Origin complex (K[3,4,5]) and Destination complex (K[3,4,5]), Rotation (0), North translation (0), and North-east translation (0) buttons, along with a Path Transformation button.
 - Chart section titled "2-compactness : bwv0281" showing a bar chart of 2-compactness values over time.

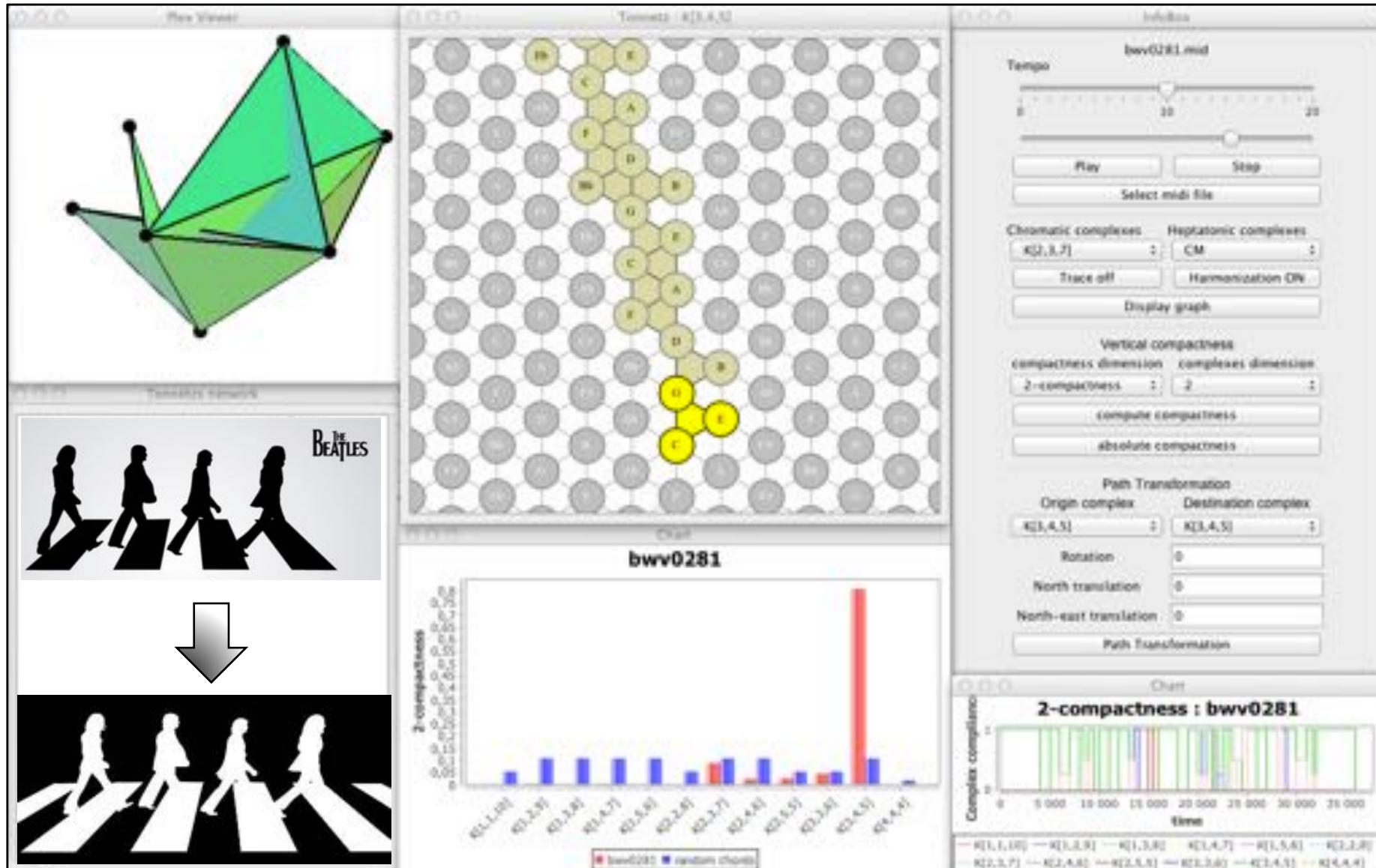
Computer Music Journal Cover:

Volume 30 Number 1, Spring 2006, pp. 1-20
Digital Harmonies and Discreet Sound Sources

The journal cover features a green background with a white header and footer. It includes a small graphic of a geometric shape and a hexagonal grid pattern.

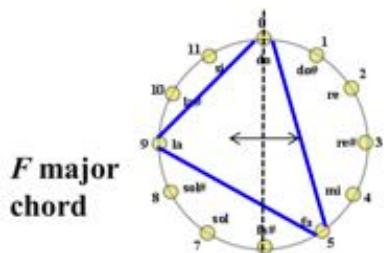
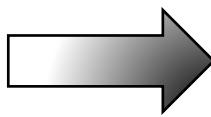
→ <http://www.lacl.fr/~lbigo/hexachord>

Keeping the space...but changing the trajectory!

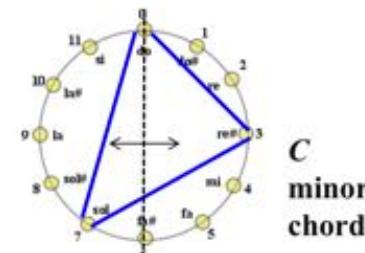


→ <http://www.lacl.fr/~lbigo/hexachord>

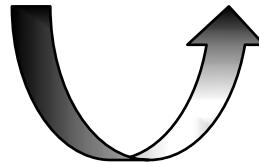
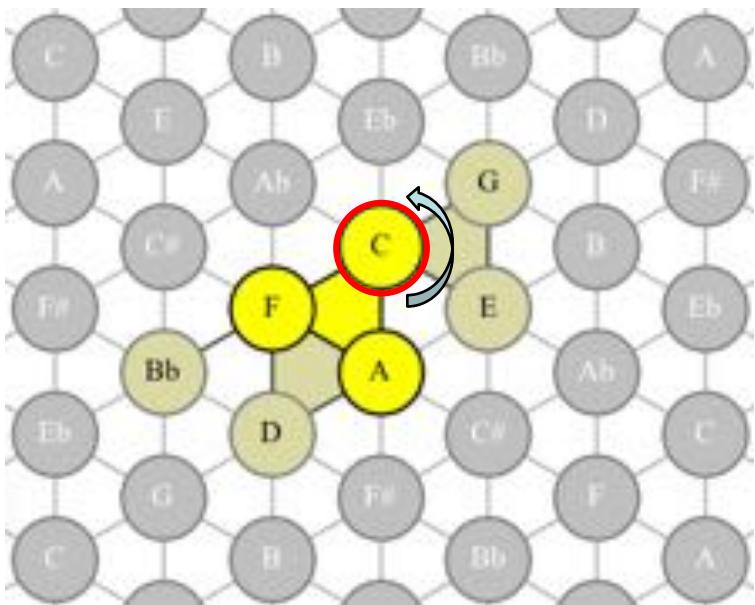
Keeping the space...but changing the trajectory!



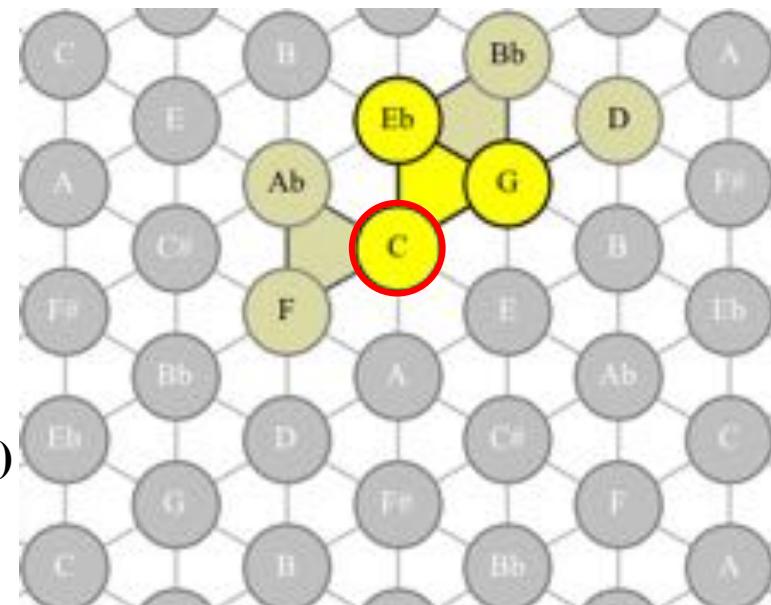
inversion



C
minor
chord



Rotation
(autour du do)

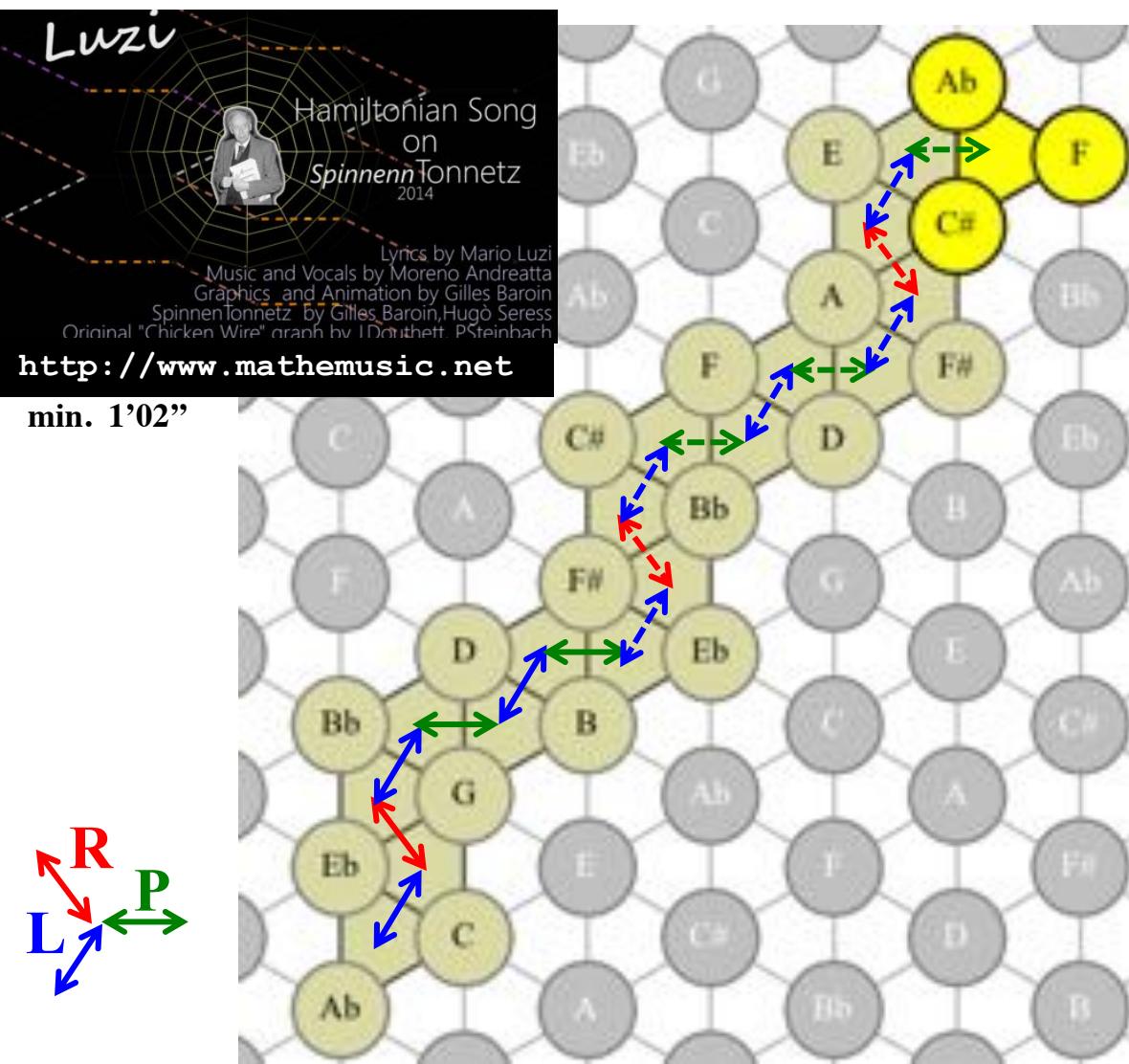


Some ‘mathemusical’ songs

- *La sera non è più la tua canzone*
(su testo di Mario Luzi)
- *Aprile*
(su testo di Gabriele d'Annunzio)
- *Domenedio*
(su testo di Livio Andreatta)
- *Una storia d'amore finisce una volta
soltanto*

Hamiltonian Cycles with inner periodicities

8. C-Cm-Eb-Gm-Bb-Dm-F-Fm-Ab-Abm-B-Ebm-F#-Bbm-C#-C#m-E-Em-G-Bm-D-F#m-A-Am--PRLRLRPR
9. C-Em-E-Abm-Ab-Cm-Eb-Gm-G-Bm-B-Ebm-F#-Bbm-Bb-Dm-D-F#m-A-C#m-C#-Fm-F-Am--LPLPLR
10. C-Em-E-Abm-B-Ebm-Eb-Gm-G-Bm-D-F#m-F#-Bbm-Bb-Dm-F-Am-A-C#m-C#-Fm-Ab-Cm--LPLRLP
11. C-Em-G-Gm-Bb-Bbm-C#-C#m-E-Abm-B-Bm-D-Dm-F-Fm-Ab-Cm-Eb-Ebm-F#-F#m-A-Am--LRPRPRPR
12. C-Em-G-Gm-Bb-Bbm-C#-Fm-Ab-Cm-Eb-Ebm-F#-F#m-A-C#m-E-Abm-B-Bm-D-Dm-F-Am--LRPRPRLR



L P L P L R ...
P L P L R L ...
L P L R L P ...
P L R L P L ...

L R L P L P ...
R L P L P L ...

La sera non è più la tua canzone (Mario Luzi, 1945, in *Poesie sparse*)

**La sera non è più la tua canzone,
è questa roccia d'ombra traforata
dai lumi e dalle voci senza fine,
la quiete d'una cosa già pensata.**

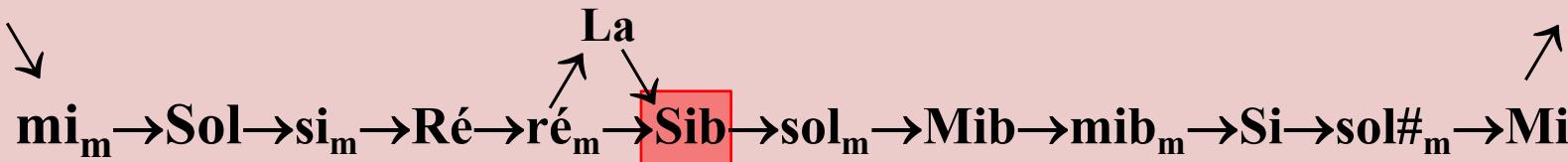
**Ah questa luce viva e chiara viene
solo da te, sei tu così vicina
al vero d'una cosa conosciuta,
per nome hai una parola ch'è passata
nell'intimo del cuore e s'è perduta.**

**Caduto è più che un segno della vita,
riposi, dal viaggio sei tornata
dentro di te, sei scesa in questa pura
sostanza così tua, così romita
nel silenzio dell'essere, (compiuta).**

**L'aria tace ed il tempo dietro a te
si leva come un'arida montagna
dove vaga il tuo spirito e si perde,
un vento raro scivola e ristagna.**

Aprile, a Hamiltonian « decadent » song

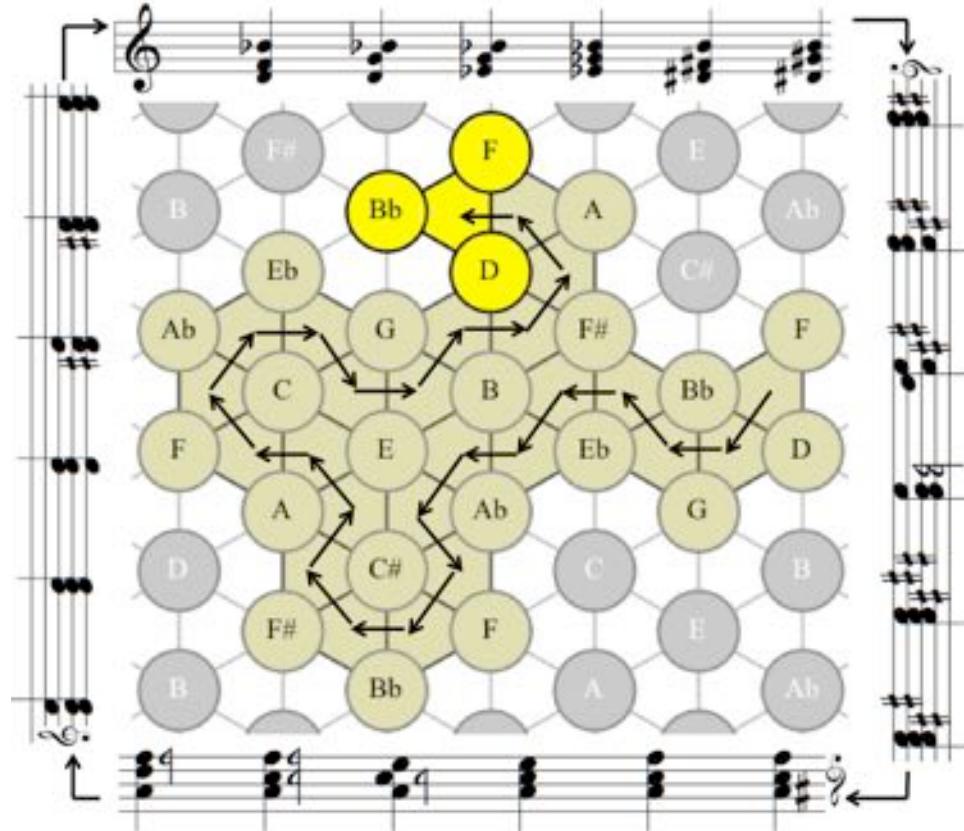
Do←**do_m**←**Sol#**←**fa_m**←**Fa**←**la_m**←**La**←**fa#_m**←**Fa#**←**sib_m**←**Do#**←**do#_m**



*Socchiusa è la finestra, sul giardino.
Un'ora passa lenta, sonnolenta.
Ed ella, ch'era attenta, s'addormenta
A quella voce che già si lamenta,
Che si lamenta in fondo a quel giardino.*

*Non è che voce d'acque su la pietra:
E quante volte, quante volte udita!
Quell'amore e quell'ora in quella vita
S'affondan come ne l'onda infinita
Stretti insieme il cadavere e la pietra.*

*Ella stende l'angoscia sua nel sonno.
L'angoscia è forte, e il sonno è così lieve!
(Par i' luce d'aprile quasi una neve
che sia tiepida.)
Ed ella certo deve soffrire,
Vagamente, anche nel sonno.*



ACTIONS

Math'n'pop

G. D'Annunzio (1863-1938)

DOMENEDIO

(‘canzone aperta’, based on a poetry by Livio Andreatta)

Quande che ero bocia
e i me parlava de Dio
el vedeva a modo mio.
En bonacion
che ‘npianta stele alpine
su pradi de brocon
e po con quele stele
l’empizza el firmament
e ‘l prova a ntrufolarse
‘nde i còri de la gent.

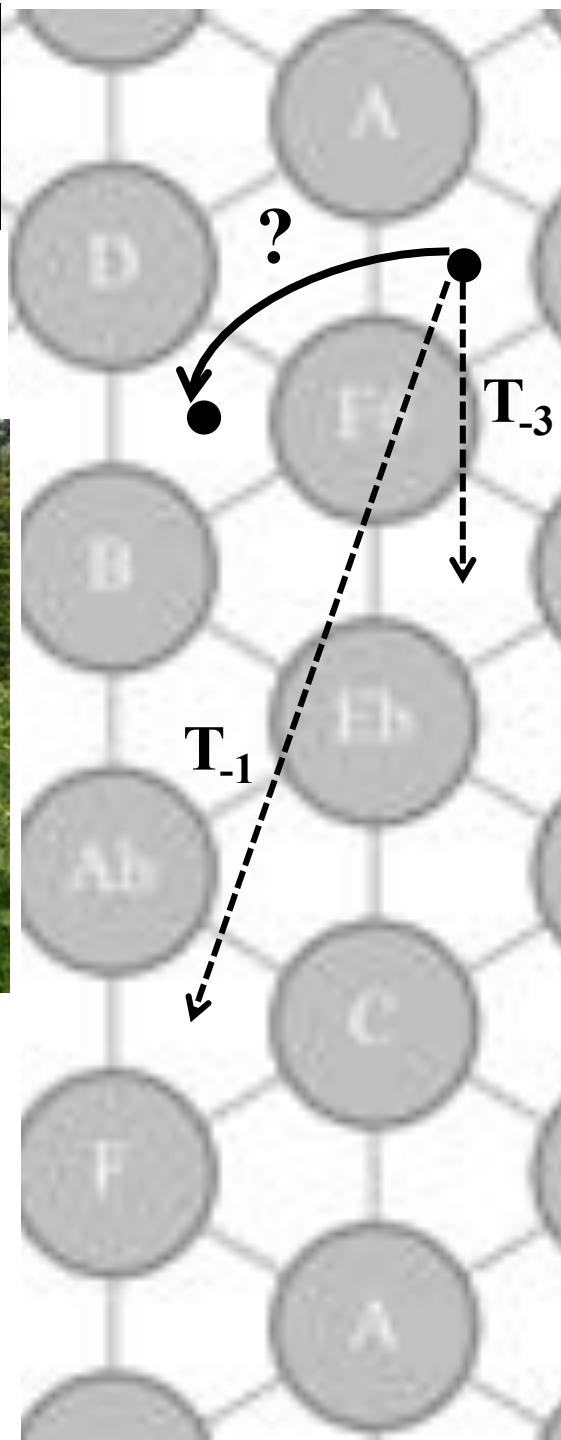
Adesso enveze...

El me dio l’è sulle strade
nol drome nde le cese
disocupà, sfrutà
macedonealbanese
Qualcun ga dit
che sol i boci
i pòl vardar Dio
drit en dei oci

el sòna la so armonica
la sera a la stazion
el drome sui cartoni
da sol e nde ‘n canton
el ga le man che tremola
l’è mez alcolizà
tel gati nde le bètole
de tuta la zitàç
el ga do oci fondi
fredi come l’inverno
oci de dona sola
oci morti de fam
oci come l’inferno



Qualcun ga dit
che sol i boci
i pòl vardar Dio
drit en dei oci
...ma no l’è vera.



A final permutional song: one sentence, one note!

Una volta soltanto una storia d'amore finisce (M. Andreatta)

**Una volta una storia d'amore
soltanto una storia**

**Una storia d'amore
soltanto una storia d'amore**

**Una storia
soltanto una storia**

**Una storia d'amore
soltanto**

**Una volta soltanto
una storia d'amore soltanto**

**Un amore soltanto una volta
soltanto una storia d'amore soltanto**

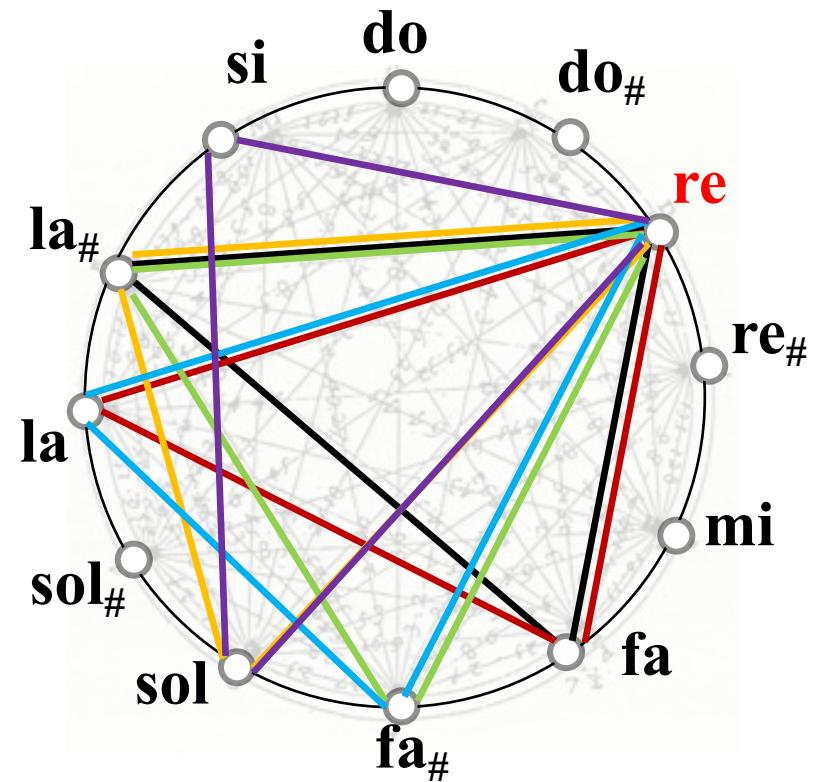
**Una storia d'amore
soltanto una volta una storia**

**Un amore
una volta soltanto**

**Un amore finisce
soltanto**

**Una volta una storia d'amore finisce
Un amore soltanto**

Una volta soltanto una storia d'amore finisce





Thank you for your attention!