

Master I.C.A.



Traitement interactif de l'image et du son

Méthodes mathématiques pour la création musicale :
aspects théoriques, informatiques et cognitifs

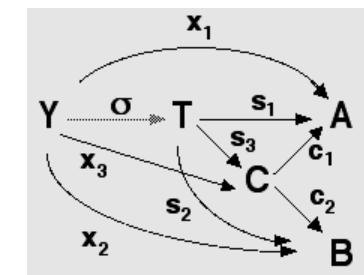
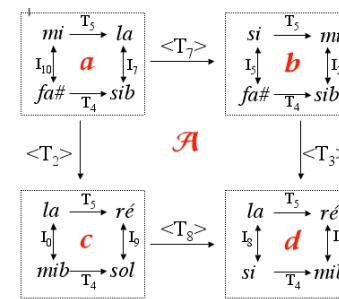
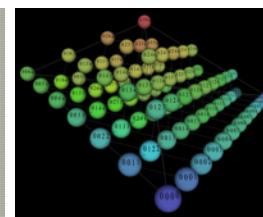
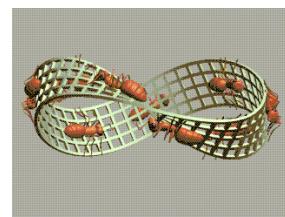
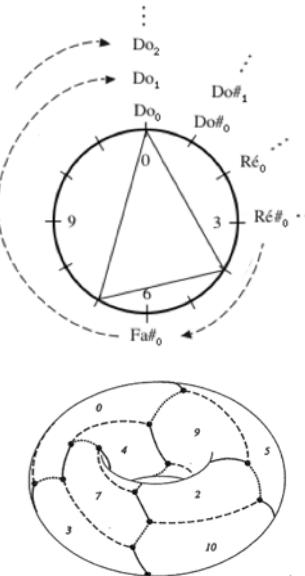
– Moreno Andreatta –

Equipe Représentations Musicales
IRCAM/CNRS/UPMC UMR 9912

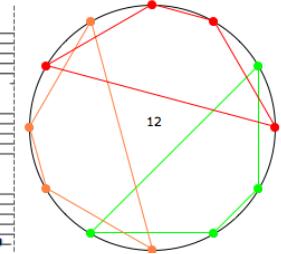
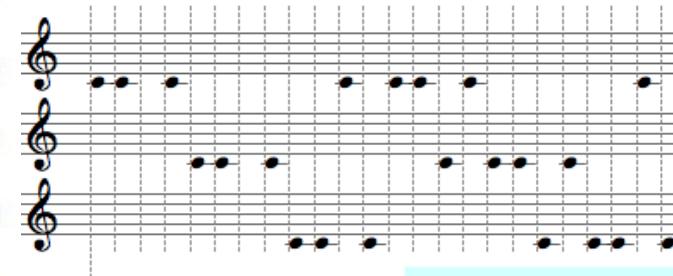
Moreno.Andreatta@ircam.fr

Plan du cours

- 1.) Rappel historique et premiers éléments de musicologie computationnelle
- 2.) Représentation et énumération des structures musicales : *Set Theory* et théories transformationnelles
- 3.) Pavages en composition : la construction des canons rythmiques mosaïques
- 4.) Ramifications philosophiques et cognitives de l'approche algébrique en musique



0 0	1 1	2 2	3 3	4 4	5 5	[6 6]
11 1	0 2	1 3	2 4	3 5	4 6	[5 7]
11 2	0 3	1 4	2 5	3 6	4 7	[4 8]
10 2	11 3	0 4	1 5	2 6	3 7	
10 3	11 4	0 5	1 6	2 7	3 8	
9 3	10 4	11 5	6 0	7 1	8 2	[9 3]
4 9	5 10	6 11	7 0	8 1	9 2	
4 8	5 9	6 10	7 11	8 0	9 1	[10 2]
5 8	6 9	7 10	8 11	9 0	10 1	
5 7	6 8	7 9	8 10	9 11	10 0	[11 1]
6 7	7 8	8 9	9 10	10 11	11 0	
6 6	7 7	8 8	9 9	10 10	11 11	[0 0]

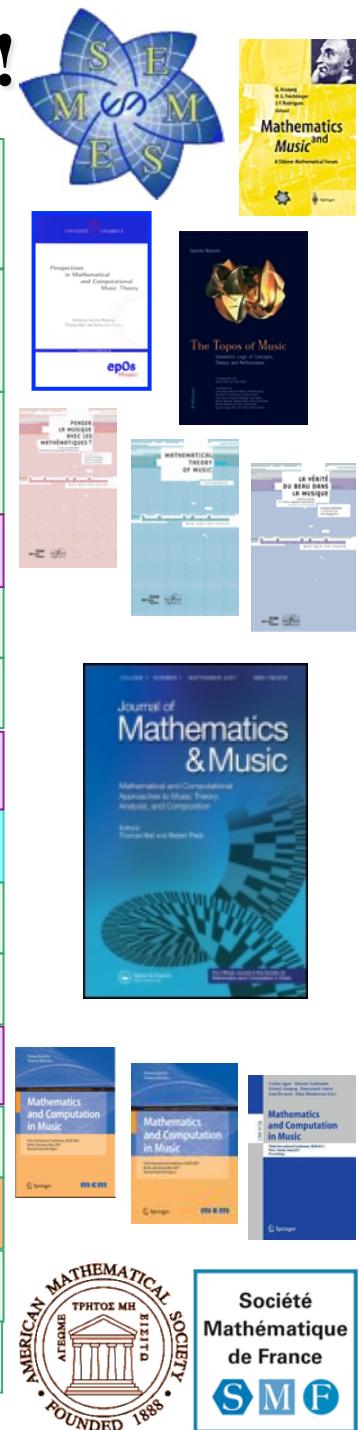


$$Df(x) = f(x) - f(x-1).$$

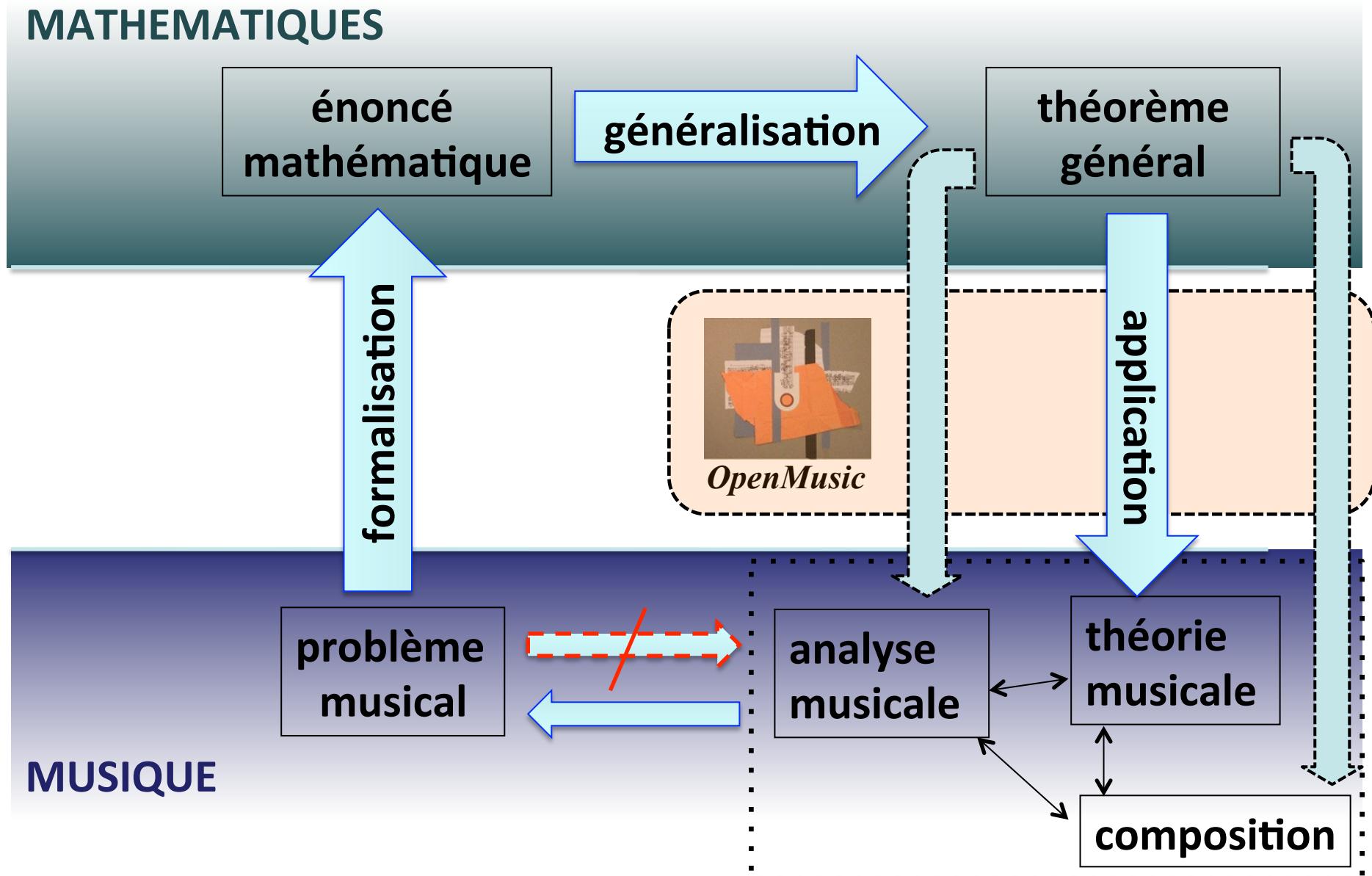
$$\begin{aligned}
 f &= 7 \underline{11} \underline{10} \underline{11} \underline{7} \underline{2} \underline{7} \underline{11} \underline{10} \underline{11} \underline{7} \underline{2} \underline{7} \underline{11} \dots \\
 Df &= 4 \underline{11} \underline{1} \underline{8} \underline{7} \underline{5} \underline{4} \underline{11} \underline{1} \underline{8} \underline{7} \underline{5} \underline{4} \underline{11} \dots \\
 D^2f &= 7 \underline{2} \underline{7} \underline{11} \underline{10} \underline{11} \underline{7} \underline{2} \underline{7} \underline{11} \underline{10} \underline{11} \dots \\
 D^3f &= 7 \underline{5} \underline{4} \underline{11} \underline{1} \underline{8} \underline{7} \underline{5} \underline{4} \underline{11} \underline{8} \dots \\
 D^k f &= \dots
 \end{aligned}$$

Mathématiques/Musique...une histoire récente !

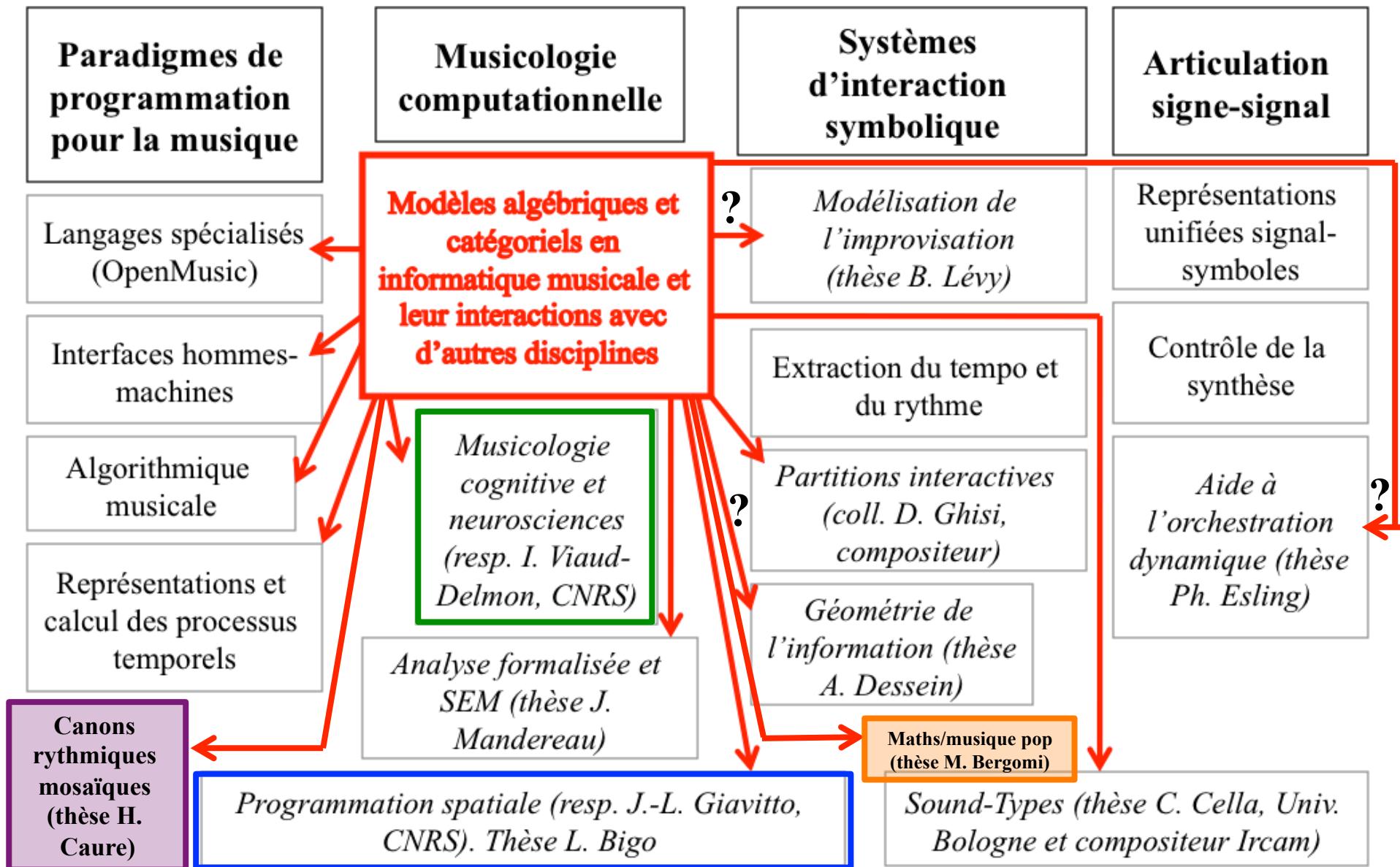
- 1999: 4^e Forum Diderot (Paris, Vienne, Lisbonne), *Mathematics and Music* (G. Assayag, H.G. Feichtinger, J.F. Rodrigues, Springer, 2001)
- 2000-2001: *MaMuPhi Seminar, Penser la musique avec les mathématiques ?* (Assayag, Mazzola, Nicolas éds., Coll. ‘Musique/Sciences’, Ircam/Delatour, 2006)
- 2000-2003: International Seminar on *MaMuTh (Perspectives in Mathematical and Computational Music Theory)* (Mazzola, Noll, Luis-Puebla eds, epOs, 2004)
- 2003: *The Topos of Music* (G. Mazzola et al.)
- 2001-....: *MaMuX Seminar* at Ircam
- 2004-....: *mamuphi Seminar* (Ens/Ircam)
- 2006: Collection ‘Musique/Sciences’ (Ircam/Delatour France)
- 2007: *Journal of Mathematics and Music* (Taylor & Francis) and SMCM
- 2007: First MCM 2007 (Berlin) and Proceedings by Springer
- 2007-....: AMS Special Session on Mathematical Techniques in Musical Analysis
- 2009: *Computational Music Science* (eds: G. Mazzola, M. Andreatta, Springer)
- 2009: MCM 2009 (Yale University) and Proceedings by Springer
- 2010: Mathematics Subject Classification : 00A65 Mathematics and music
- 2011: MCM 2011 (Ircam, 15-17 June 2011) and Proceedings LNCS Springer
- 2013: MCM 2013 (McGill University, Canada, 12-14 June 2013) - Springer



Double mouvement d'une dynamique mathémusicale



La musicologie computationnelle au sein de RepMus



La place des mathématiques dans la musicologie systématique

Guido Adler : « Umfang, Methode und Ziel der Musikwissenschaft » (1885)

II. Systematisch.

Aufstellung der in den einzelnen Zweigen der Tonkunst zuhöchst stehenden Gesetze.

A. Erforschung und Begründung derselben in der

1. Harmo-
nik
(tonal od.
tonlich).
2. Rhyth-
mik
(temporär
oder
zeitlich).
3. Melik
(Cohärenz
von tonal
und tem-
porär).

B. Aesthetik der Tonkunst.

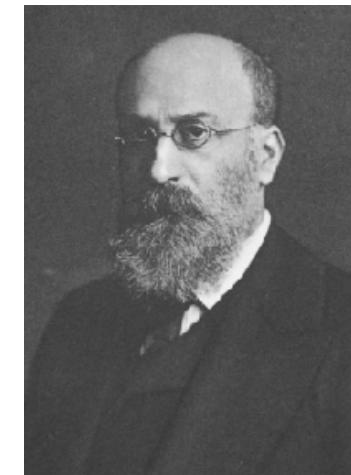
1. Vergleichung und Werthschätzung der Gesetze und deren Relation mit den appercipirenden Subjecten behufs Feststellung der *Kriterien des musikalisch Schönen.*
2. Complex unmittelbar und mittelbar damit zusammenhängender Fragen.

C. Musikalische Pädagogik und Didaktik (Zusammenstellung der Gesetze mit Rücksicht auf den Lehrzweck)

1. Tonlehre,
2. Harmonielehre,
3. Kontrapunkt,
4. Compositionslehre,
5. Instrumentationslehre,
6. Methoden des Unterrichtes im Gesang und Instrumentalspiel.

D. Musi- kologie (Unter- suchung und Ver- gleichung zu ethno- graphi- schen Zwecken).

Hilfswissenschaften: Akustik und Mathematik.
Physiologie (Tonempfindungen).
Psychologie (Tonvorstellungen, Tonurtheile und Tongefühle).
Logik (das musikalische Denken).
Grammatik, Metrik und Poetik.
Pädagogik
Ästhetik etc.



G. Adler (1855-1941)



R. Parncutt

« La deuxième grande partie de la musicologie est la partie systématique; cette partie se base sur la partie historique. (...) L'accent de l'observation réside dans l'analogie de la méthode musicologique avec la méthode scientifique ».

Un court survol historique

MUSIQUE	MATHS
500 av. J. C. Relation hauteur/longueur corde. La musique est source d'inspiration pour la théorie des nombres et la géométrie.	Nombres naturels et rationnels
300 a.J. Invention (théorique) de la gamme chromatique tempérée égale par Atistoxène de Tarente) et prémonition de la théorie des groupes. Isomorphismes entre les logarithmes (intervalles musicaux) et les exponentiels (longueur d'une corde)	<i>Aucune relation.</i>
1000 Invention de la représentation bidimensionnelle des hauteurs	<i>Aucune correspondance</i>
1500 Aucune reprise des concepts précédents	Nombres négatifs. Construction des rationnels
1600 Aucune relation	Nombres réels et les logarithmes
Marin Mersenne (1588-1648) : combinatoire musicale	Calcul des probabilités
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)
Leonhard Euler : Speculum Musicum (1773)	Théorie des graphes
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.
Ernst Krenek (1900-1991) : les axiomes dans le système dodécaphonique	David Hilbert, <i>Les fondements de la géométrie</i> (1899)

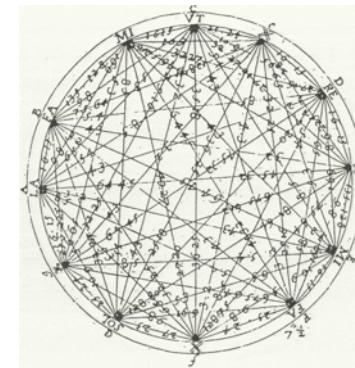
Iannis Xenakis, *Musique. Architecture*, Tournai, Casterman, 1971, 176 p. (New, revised edition: Tournai, Casterman, 1976, 238 p.)



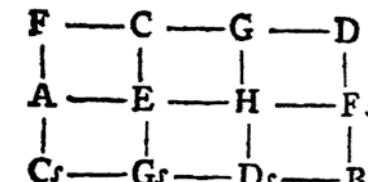
Pythagore et le monocorde, VI^e-V^e siècle av. J. C.



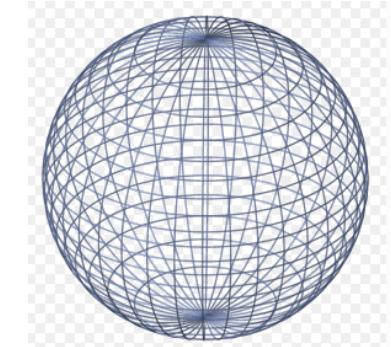
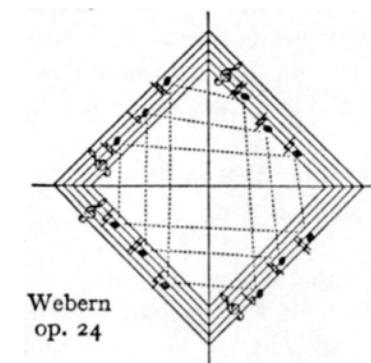
I. Xenakis



Mersenne,
*Harmonicorum
Libri XII*, 1648

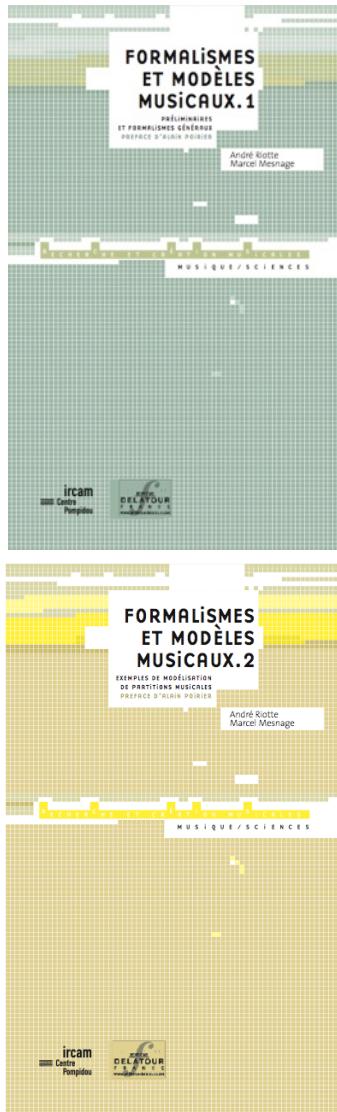
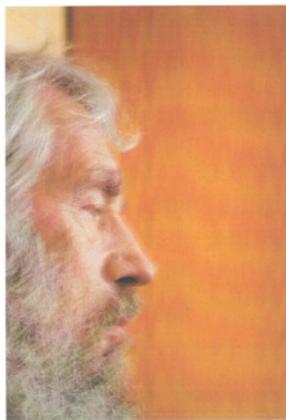


Euler : *Speculum
musicum*, 1773



L'analyse formalisée ou les entités formelles en musique

André Riotte e Marcel Mesnage



- « Anamorphoses » d'André Riotte
- « La terrasse des audiences du clair de lune » de Claude Debussy : esquisse d'analyse modélisée
- La mise en évidence de régularités locales : le « Mode de valeurs et d'intensités » de Messiaen
- Un exemple d'invention structurelle : le « Mikrokosmos » de Béla Bartok
- Un modèle informatique de la « Pièce pour quatuor à cordes » n°1 de Stravinsky
- Les « Variations pour piano », op. 27, d'Anton Werbern
- L'« Invention à deux voix » n°1 de J.-S. Bach
- Un modèle informatique du « Troisième Regard sur l'Enfant Jésus » d'Olivier Messiaen
- Un modèle de la « Valse sentimentale », Op. 50, n°13, de Franz Schubert
- Un automate musical construit à partir d'une courte pièce de Béla Bartok (Mikrokosmos n°39)

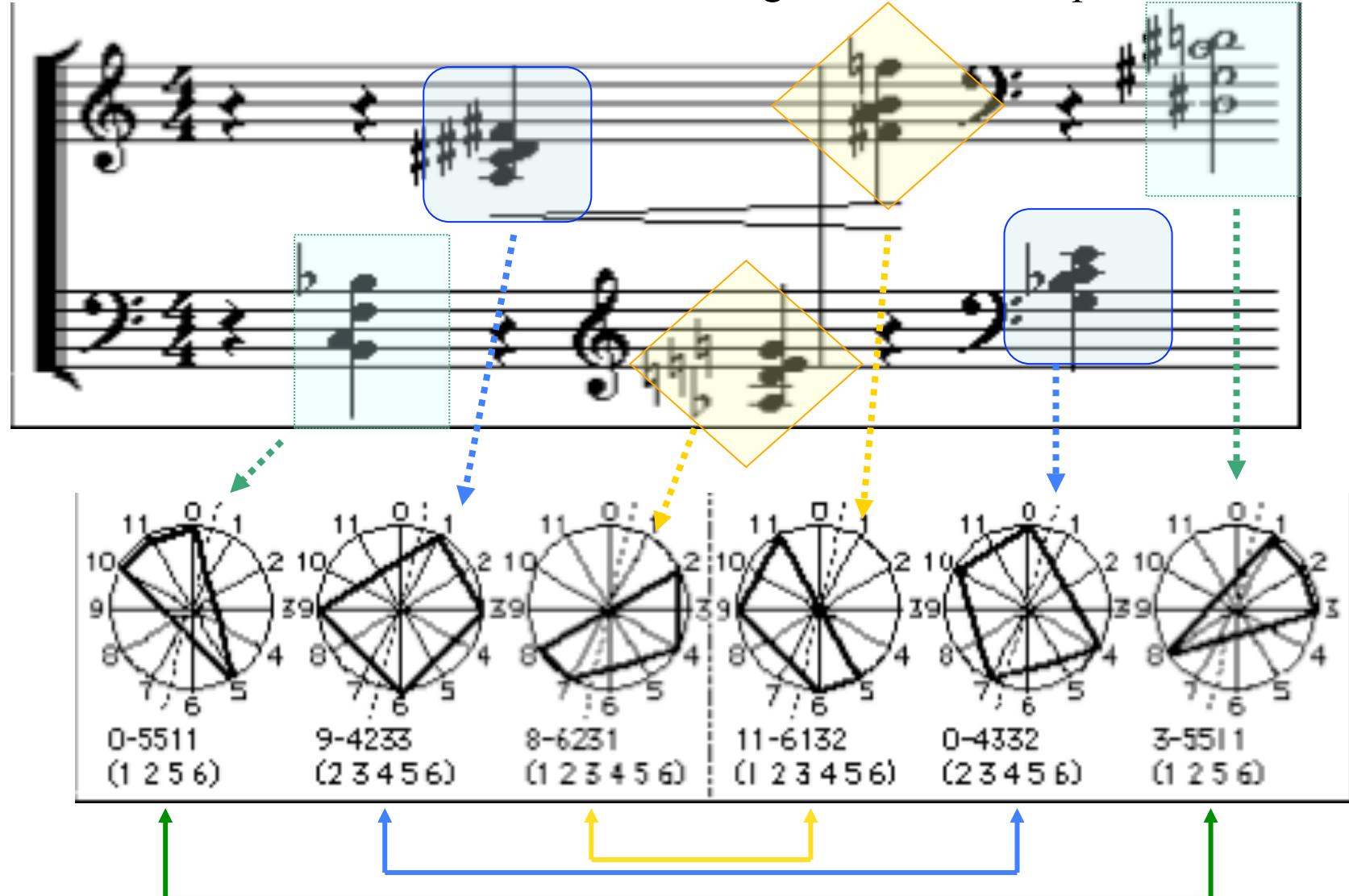
A. Riotte & M. Mesnage, *Formalismes et modèles musicaux* (en 2 volumes), Collection « Musique/Sciences », Ircam/Delatour France, 2006



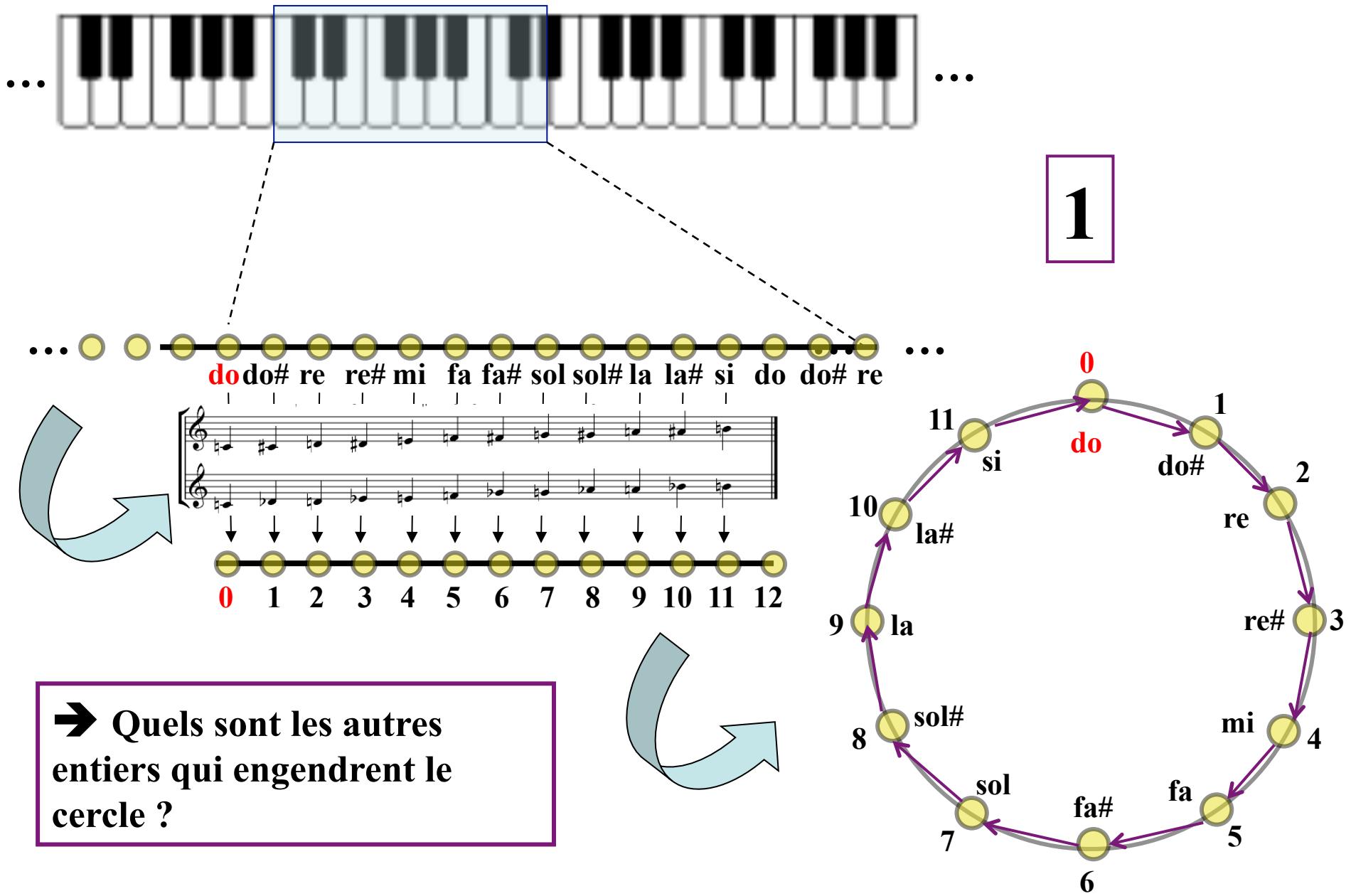
« Entités formelles pour l'analyse musicale »

Marcel Mesnage (1998)

A. Schoenberg : *Klavierstück Op. 33a*, 1929



Reduction à l'octave et congruence modulo 12

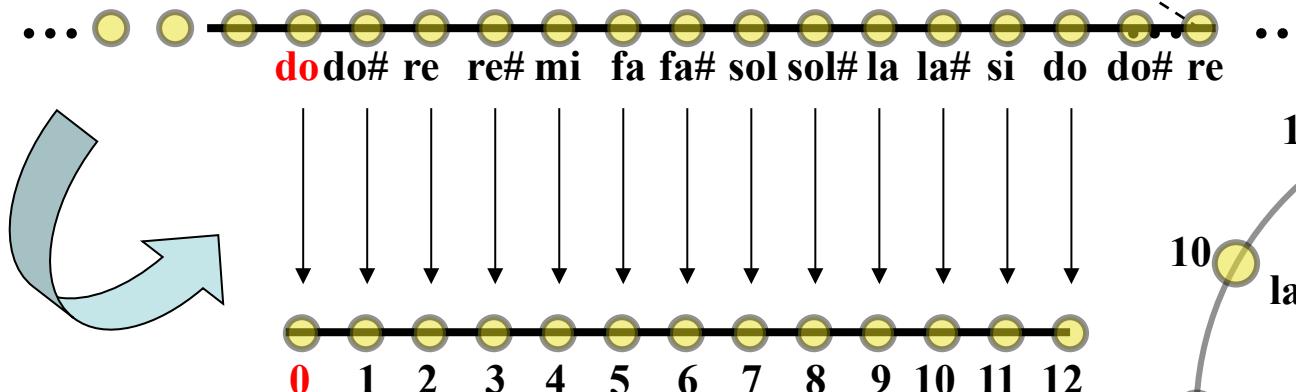


Reduction à l'octave et congruence modulo 12

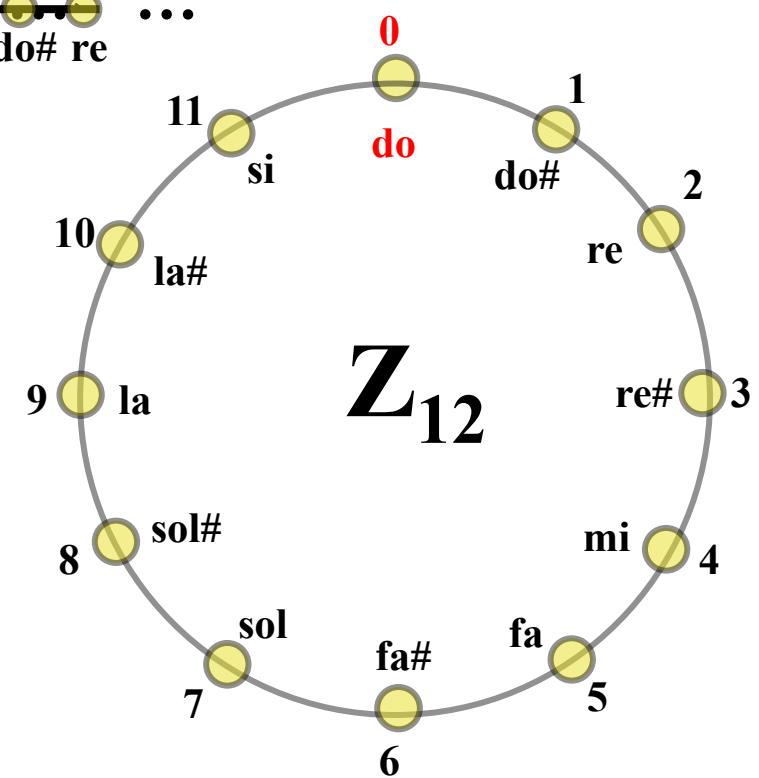
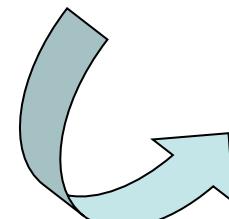


$$Z_{12} = \langle T_k \mid (T_k)^{12} = T_0 \rangle$$

$$T_k : x \rightarrow x+k \bmod 12$$



→ Les générateurs du groupe cyclique d'ordre 12 sont les transpositions T_1 , T_5 , T_7 et T_{11}

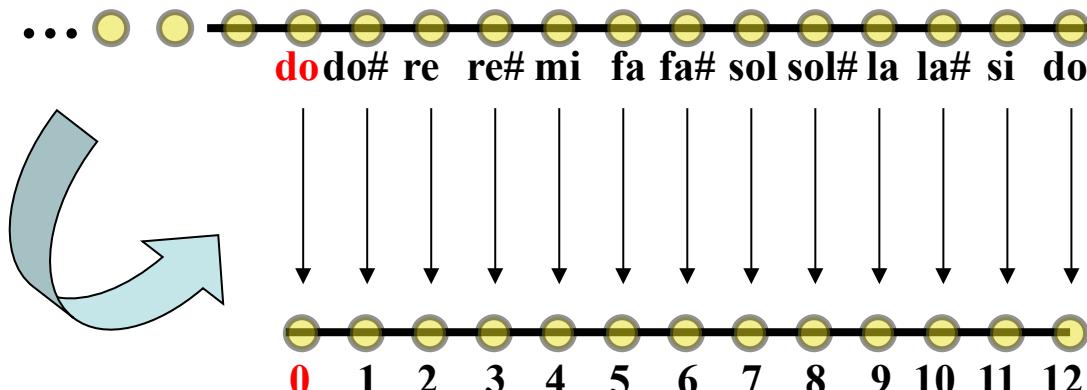


Reduction à l'octave et congruence modulo 12

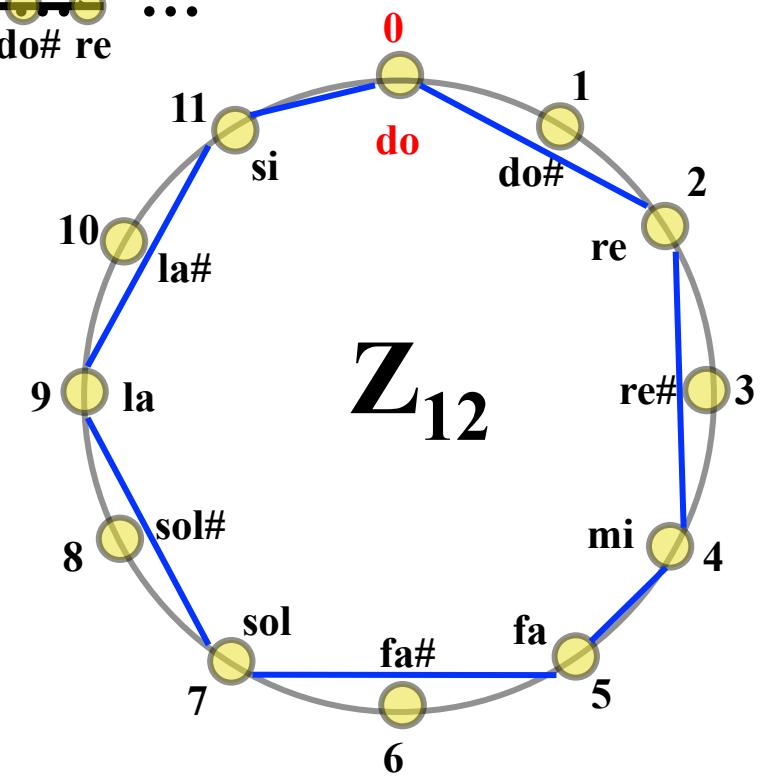


$$Z_{12} = \langle T_k \mid (T_k)^{12} = T_0 \rangle$$

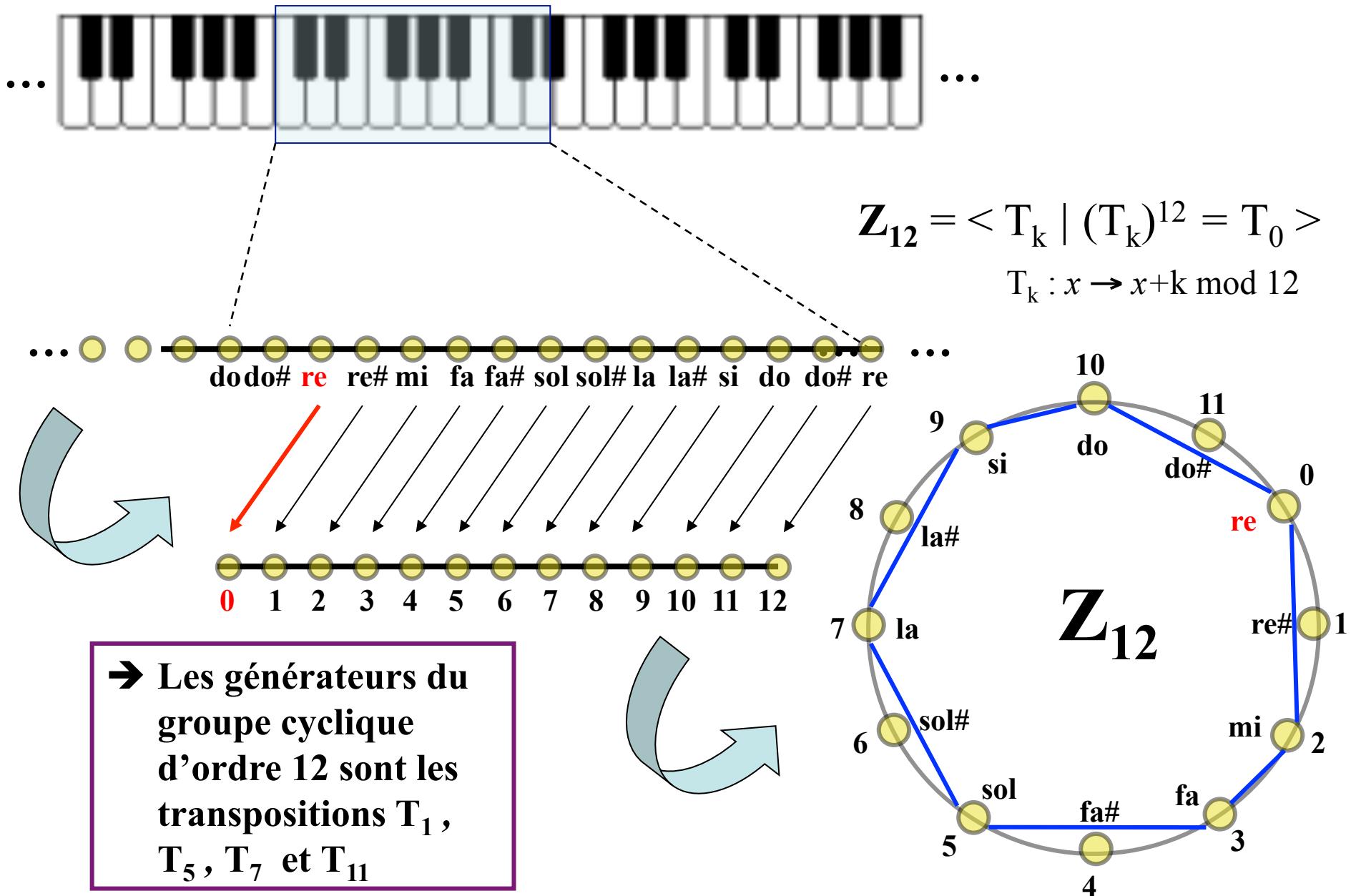
$$T_k : x \rightarrow x+k \bmod 12$$



→ Les générateurs du groupe cyclique d'ordre 12 sont les transpositions T_1 , T_5 , T_7 et T_{11}



Reduction à l'octave et congruence modulo 12



La symétrie du ré...

*Nordwijk souvenance
C. Durutte*

ESTHÉTIQUE MUSICALE.

TECHNIE

LOIS GÉNÉRALES DU SYSTÈME HARMONIQUE,

par le Comte CAMILLE DURUTTE, d'Ypres,

Compositeur, sociétaire de l'École polytechnique, Membre de l'Académie Impériale de Musique.



PARIS,
MAILLET-GACHELIER,

IMPRIMEUR-ÉDITEUR DE L'ÉCOLE POLYTECHNIQUE,
quai des Grands-Augustins, 35.

E. GIROD,
IMPRIMEUR DE MUSIQUE MODERNE,
boulevard Malesherbes, 16.

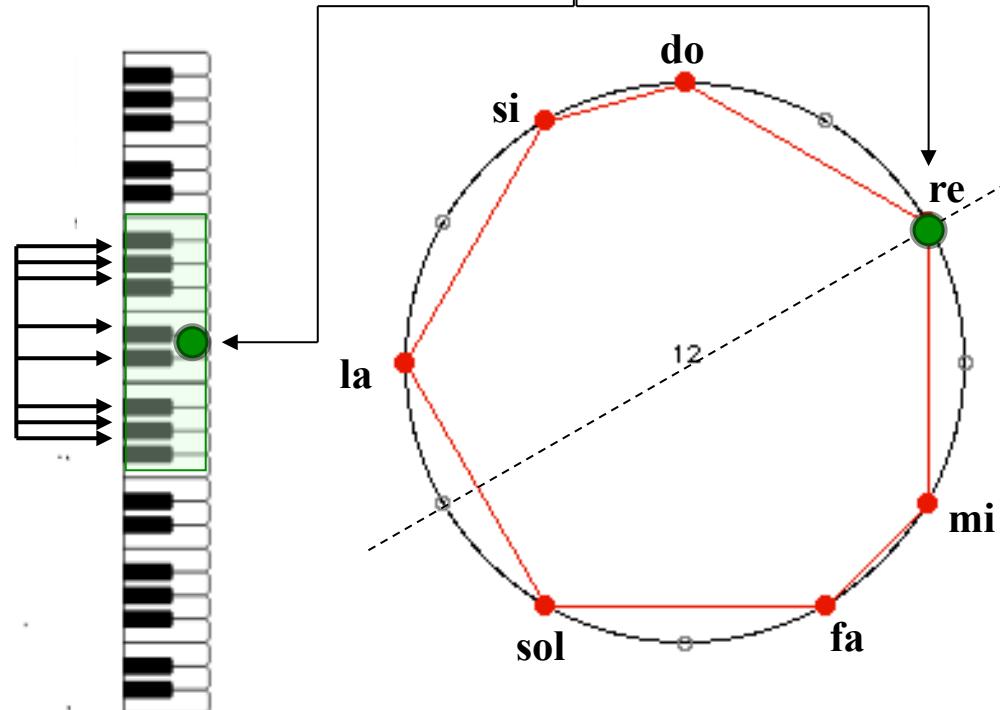
MEZZ,
Typographie de ROUSSEAU-PALLETZ, Éditeur,
IMPRIMEUR DE MUSIQUE MODERNE,
rue des Ursins, 16.

1855.

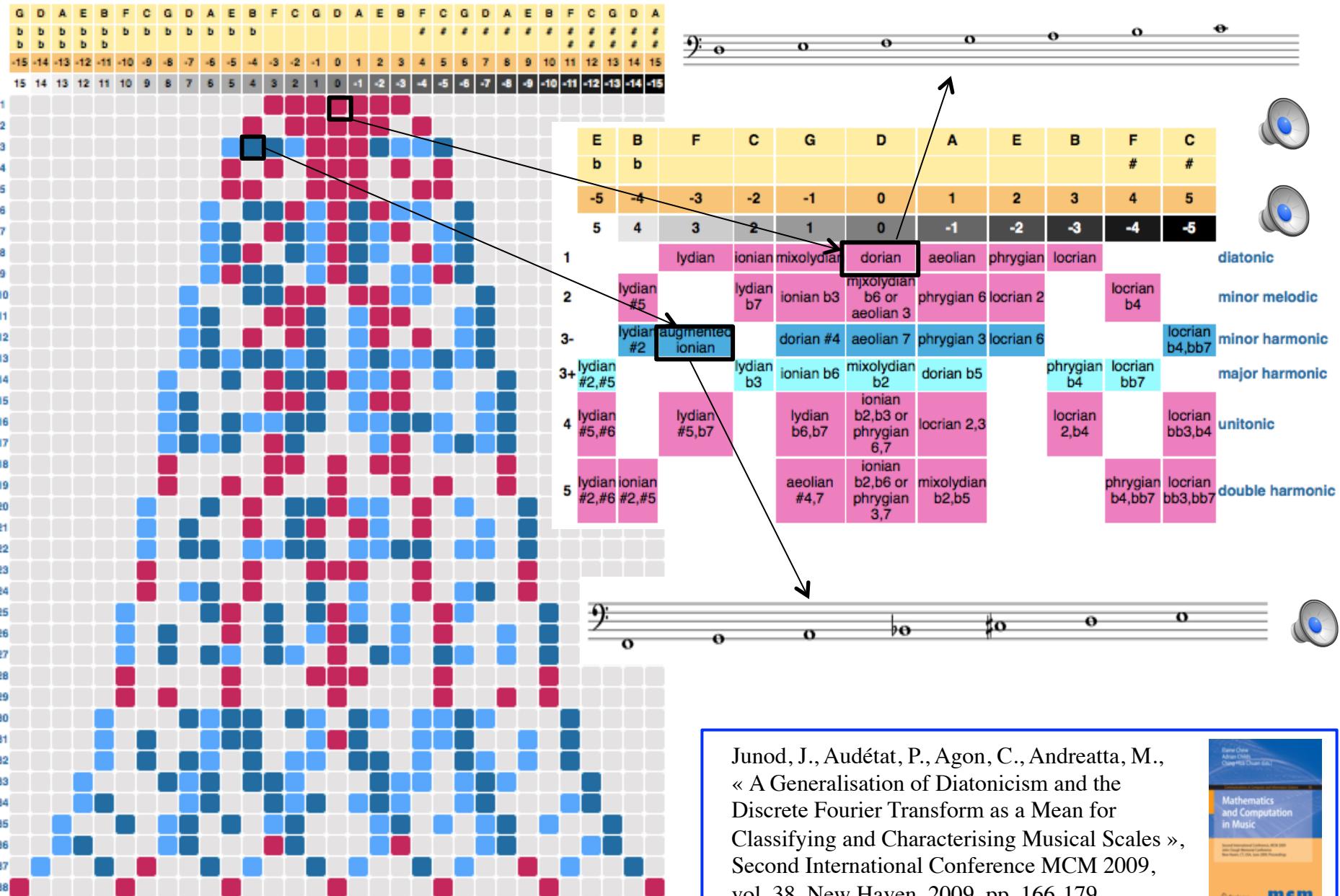
Camille Durutte:

- *Technie, ou lois générales du système harmonique* (1855)
- *Résumé élémentaire de la Technie harmonique, et complément de cette Technie* (1876)

Sol	Re	Fa	Ut	Sol	Re	La	Mi	Si	.....	Re	X	La	X
-15	-14	.....	-3	-2	-1	0	+1	+2	+3	.....	+14	+15	

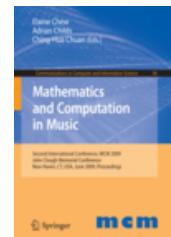


La cloche diatonique (P. Audétat & co.)



<http://www.cloche-diatonique.ch/>

Junod, J., Audétat, P., Agon, C., Andreatta, M.,
« A Generalisation of Diatonicism and the
Discrete Fourier Transform as a Mean for
Classifying and Characterising Musical Scales »,
Second International Conference MCM 2009,
vol. 38, New Haven, 2009, pp. 166-179



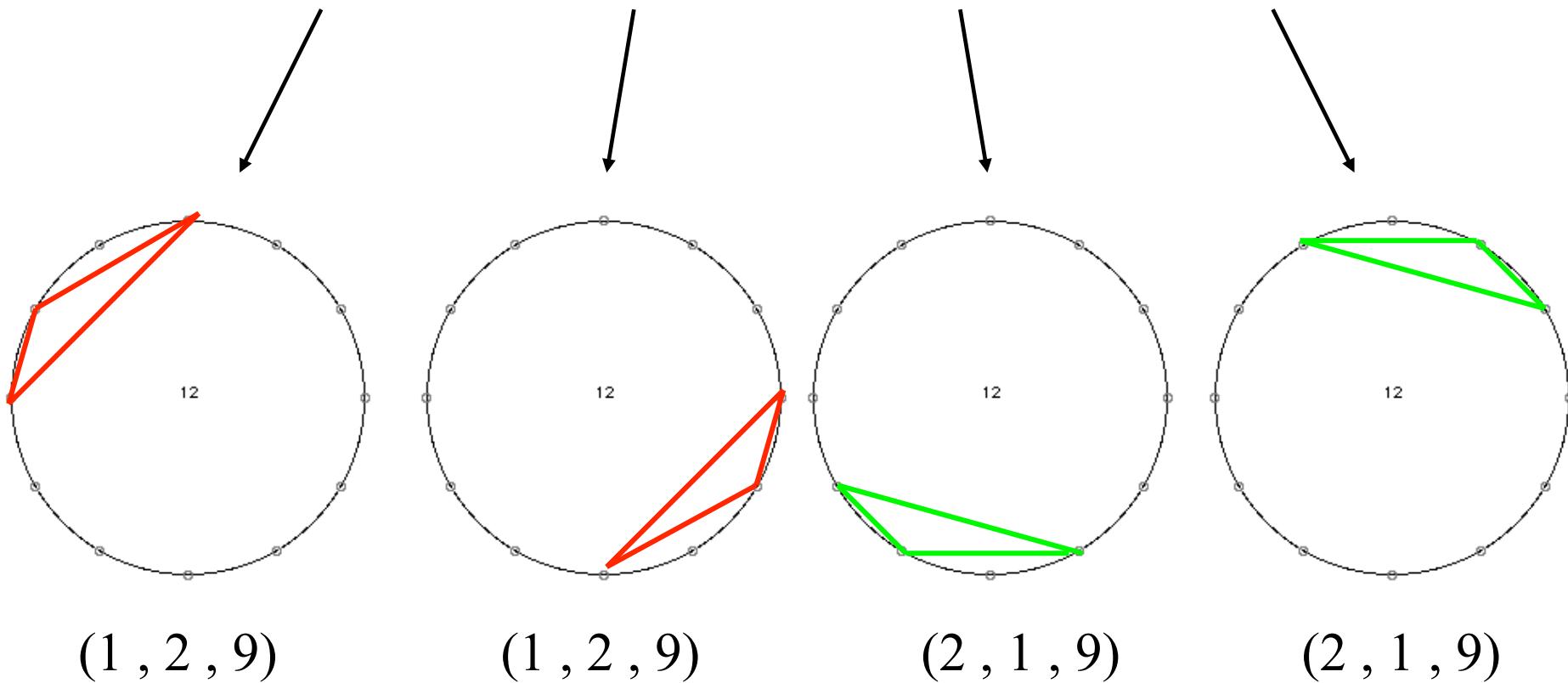
Exercice : retrouver les symétries dans une série (I)

Schoenberg: Serenade Op.24, Mouvement 5

A musical staff in G clef with four measures. Red boxes highlight specific groups of notes in each measure. Arrows point from these boxes to corresponding circle diagrams below.

Below the staff are four sets of numbers:

- {9 , 10 , 0}
- {3 , 4 , 6}
- {5 , 7 , 8}
- {11 , 1 , 2}



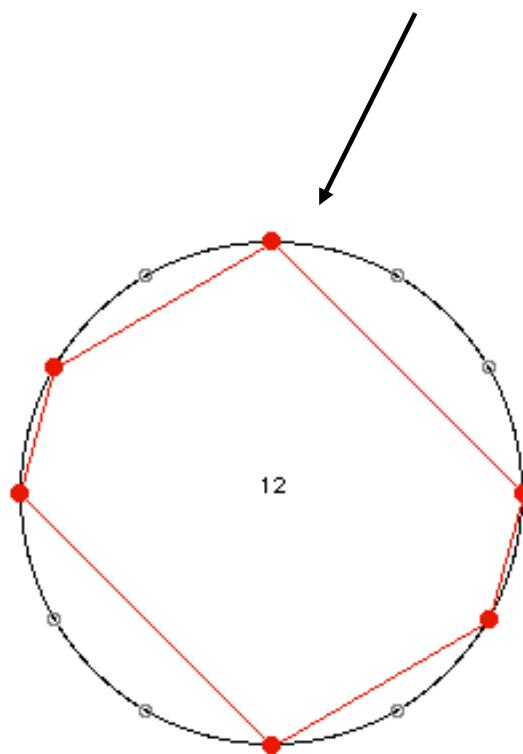
Exercice : retrouver les symétries dans une série (II)

Schoenberg: Serenade Op.24, Mouvement 5

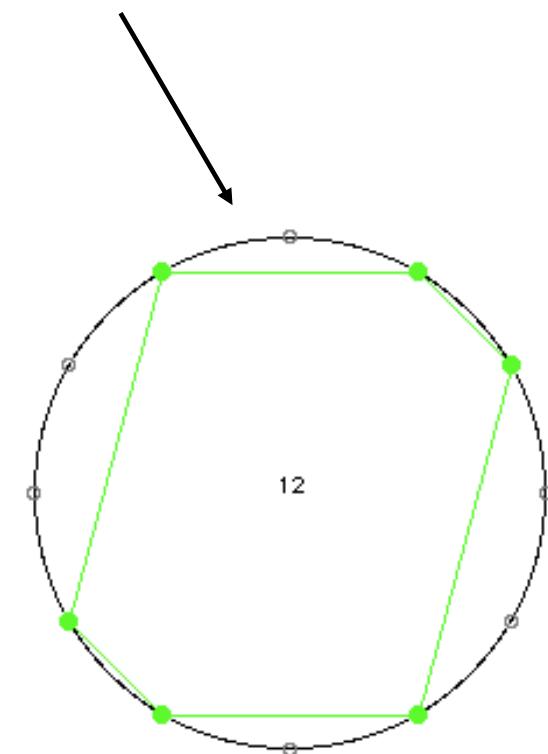
The musical excerpt consists of two six-note melodic segments on a treble clef staff. The first segment is enclosed in a red box, and the second is in a green box. Below each segment is a vertical stack of six arrows pointing downwards, corresponding to the notes in each segment.

$\{9, 10, 0, 3, 4, 6\}$

$\{5, 7, 8, 11, 1, 2\}$



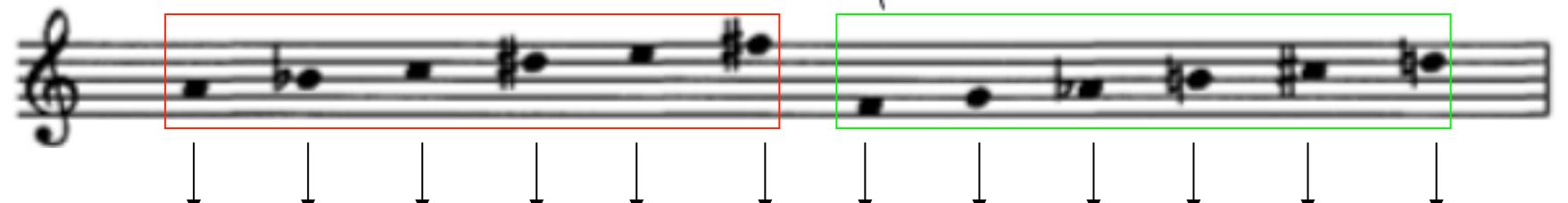
$(3, 1, 2, 3, 1, 2)$



$(2, 1, 3, 2, 1, 3)$

“Combinatorialité” et symétrie par transposition

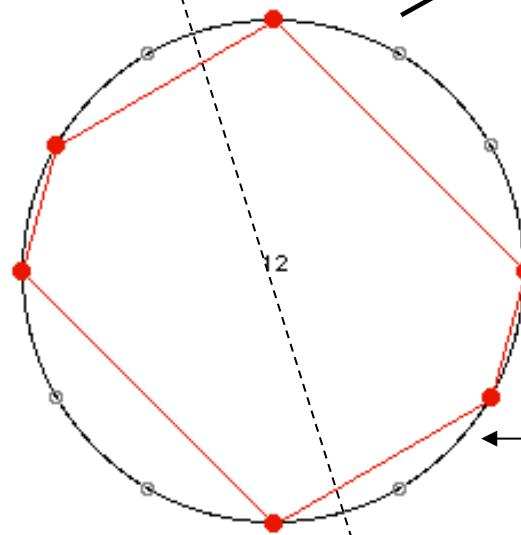
Schoenberg: Serenade Op.24, Mouvement 5



$$A = \{9, 10, 0, 3, 4, 6\} \quad \{5, 7, 8, 11, 1, 2\} = A'$$

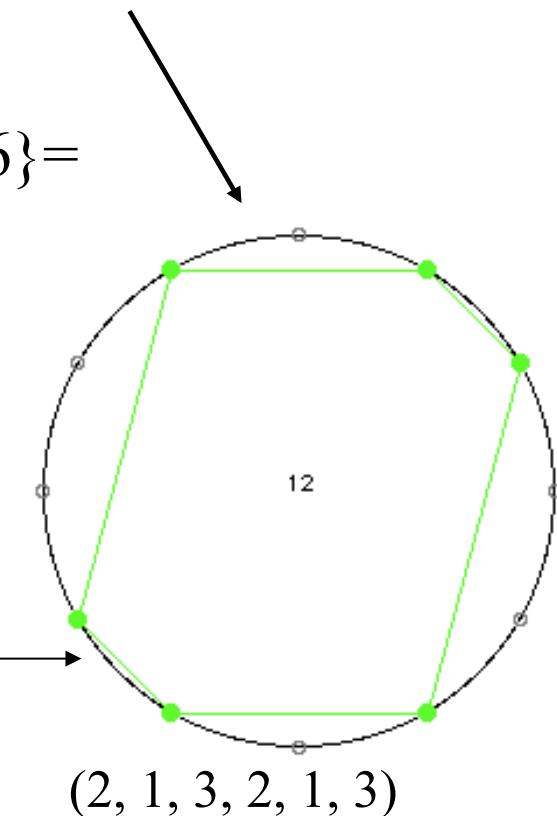
$$\begin{aligned} T6\{9,10,0,3,4,6\} &= \\ &= \{6+9, 6+10, 6, 6+3, 6+4, 6+6\} = \\ &= \{3, 4, 6, 9, 10, 0\} \end{aligned}$$

$$T6(A) = A$$



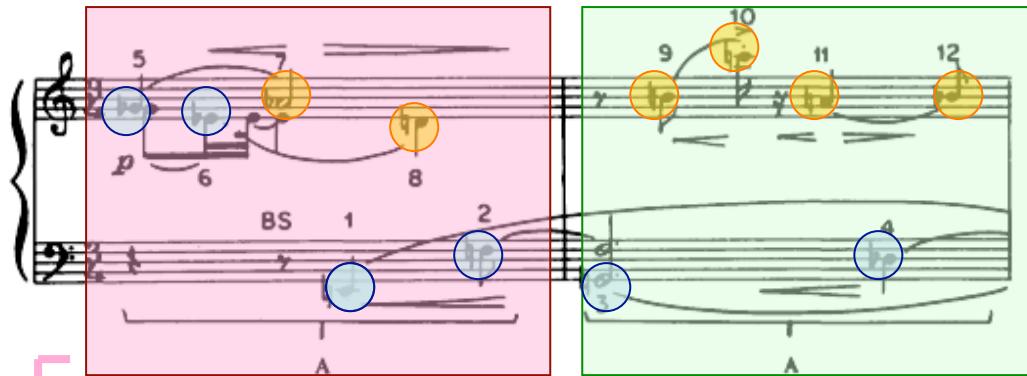
(3, 1, 2, 3, 1, 2)

$$I_{11} = T_{11} I$$

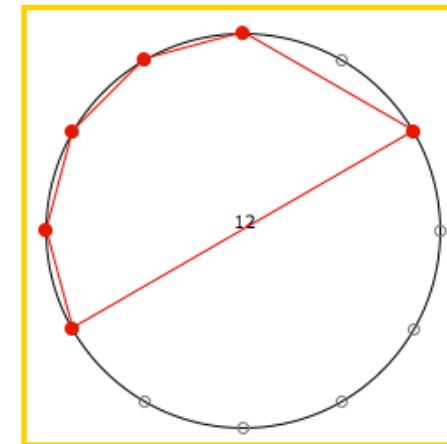
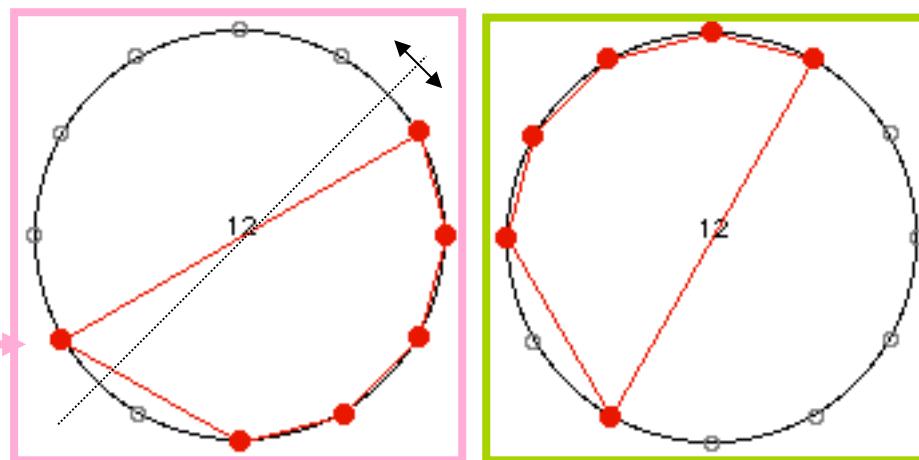
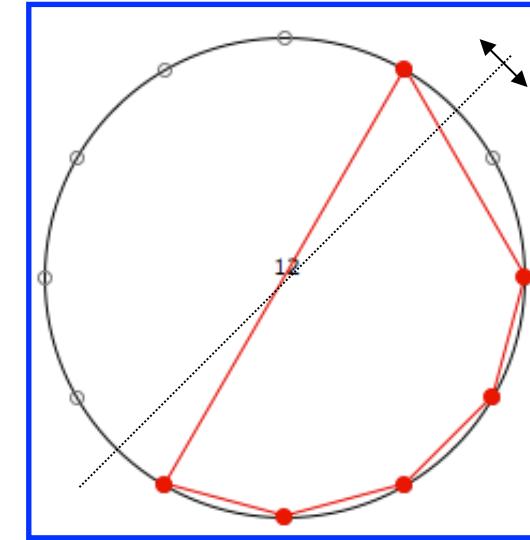


(2, 1, 3, 2, 1, 3)

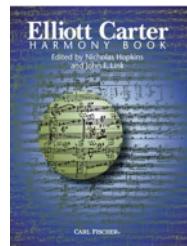
Serialisme and hexachordal combinatoriality



Schoenberg: Suite Op.25, Minuetto



Set Theory chez Elliott Carter



- Combinatoire d'accords
 - Hexacordes
 - Tétracordes
 - Triades
 - Relation Z

- Séries tous-intervalles
 - *Link-chords*



(piano: John Snijders)

mille e novanta auguri a caro Goffredo

90+

Elliott Carter
(1994)

* Use pedal only to join one chord to another *legato*, as in mm. 1–13, 16–21, 36–43, and 45–48.

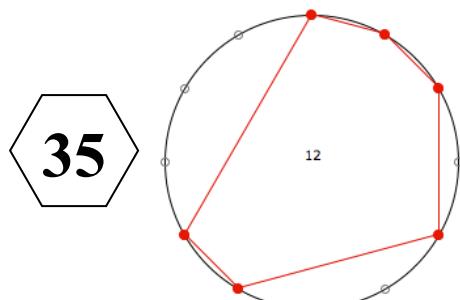
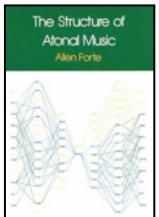
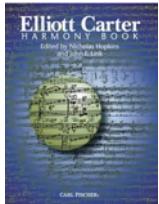
© Copyright 1994 by Hendon Music, Inc.
a Boosey & Hawkes Company.
Copyright for all countries. All rights reserved.

PIB 503

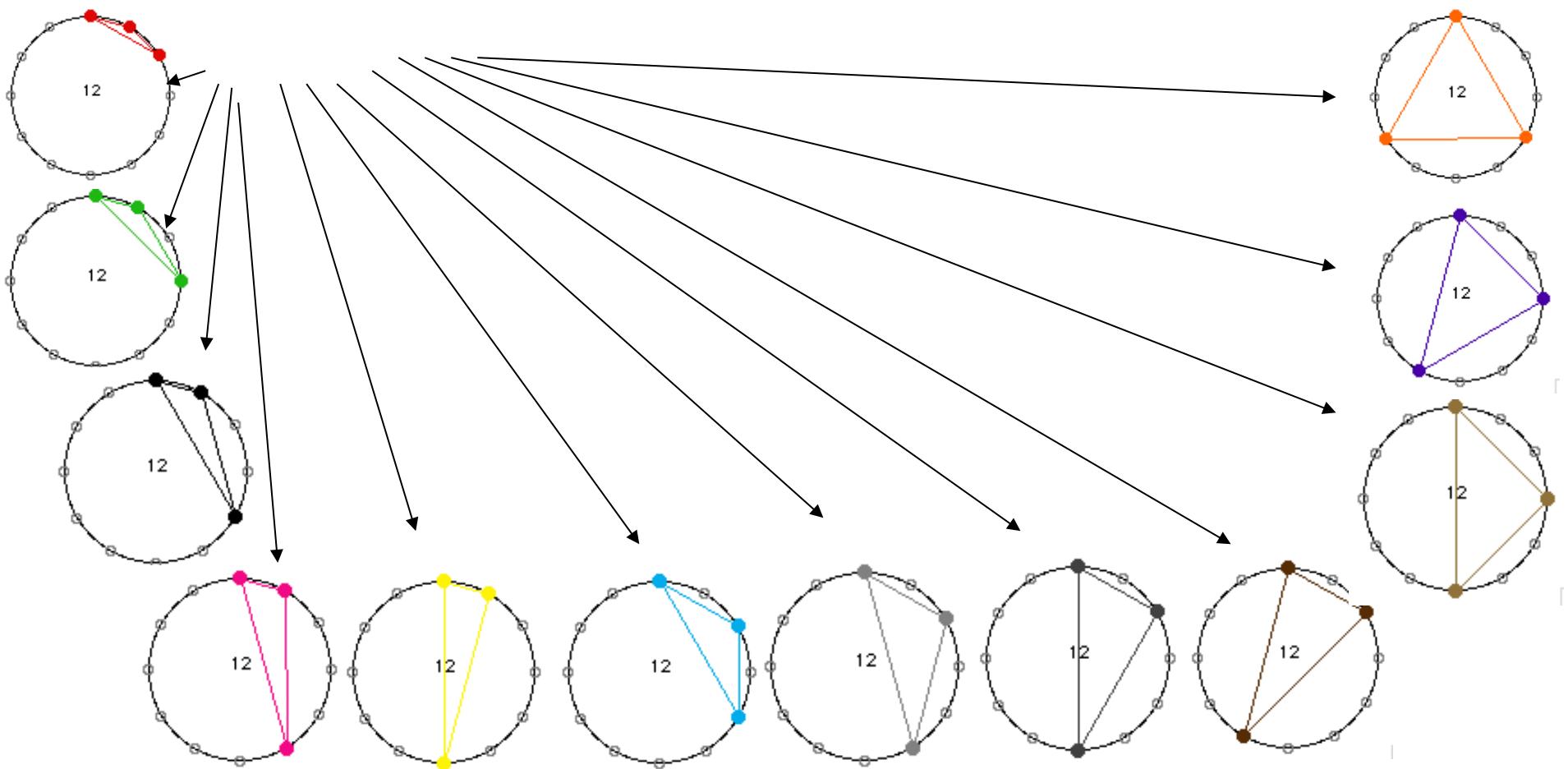
Printed in U.S.A.

Combinatoire d'hexacordes

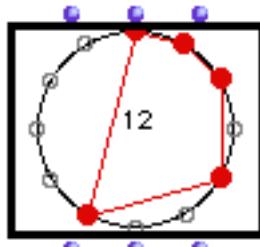
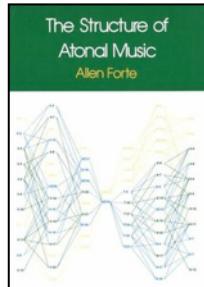
$G \setminus k$	1	2	3	4	5	6	7	8	9	10	11	12
C_{12}	1	6	19	43	66	80	66	43	19	6	1	1
D_{12}	1	6	12	29	38	50	38	29	12	6	1	1
$\text{Aff}_1(Z_{12})$	1	5	9	21	25	34	25	21	9	5	1	1



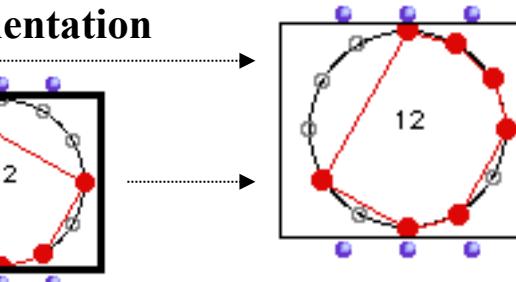
pcset *vector* *name*
(0 1 2 4 7 8) [322332] 6-Z17
All-triad hexachord



Le catalogue des *pcs* d'Allen Forte (1973) et la relation Z



complémentation



A. Forte (1926-)

5-30	0,1,4,6,8	121321
5-31	0,1,3,6,9	114112
5-32	0,1,4,6,9	113221
5-33(12)	0,2,4,6,8	040402
5-34(12)	0,2,4,6,9	032221
5-35(12)	0,2,4,7,9	032140
5-Z36	0,1,2,4,7	222121
5-Z37(12)	0,3,4,5,8	212320
5-Z38	0,1,2,5,8	212221
6-1(12)	0,1,2,3,4,5	543210
6-2	0,1,2,3,4,6	443211

5-Z36 **0,1,2,4,7** **222121**

6-Z4(12)	0,1,2,4,5,6	432321
6-5	0,1,2,3,6,7	422232
6-Z6(12)	0,1,2,5,6,7	421242
6-7(6)	0,1,2,6,7,8	420243
6-8(12)	0,2,3,4,5,7	343230
6-9	0,1,2,3,5,7	342231
6-Z10	0,1,3,4,5,7	333321
6-Z11	0,1,2,4,5,7	333231
6-Z12	0,1,2,4,6,7	332232
6-Z13(12)	0,1,3,4,6,7	324222

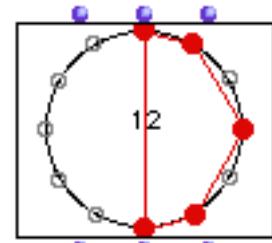
/-30	0,1,2,4,6,8,9	343542
7-31	0,1,3,4,6,7,9	336333
7-32	0,1,3,4,6,8,9	335442
7-33	0,1,2,4,6,8,10	262623
7-34	0,1,3,4,6,8,10	254442
7-35	0,1,3,5,6,8,10	254361
7-Z36	0,1,2,3,5,6,8	444342
7-Z37	0,1,3,4,5,7,8	434541
7-Z38	0,1,2,4,5,7,8	434442

7-Z36 **0,1,2,3,5,6,8** **444342**

6-Z37(12) 0,1,2,3,4,8

6-Z38(12) 0,1,2,3,7,8

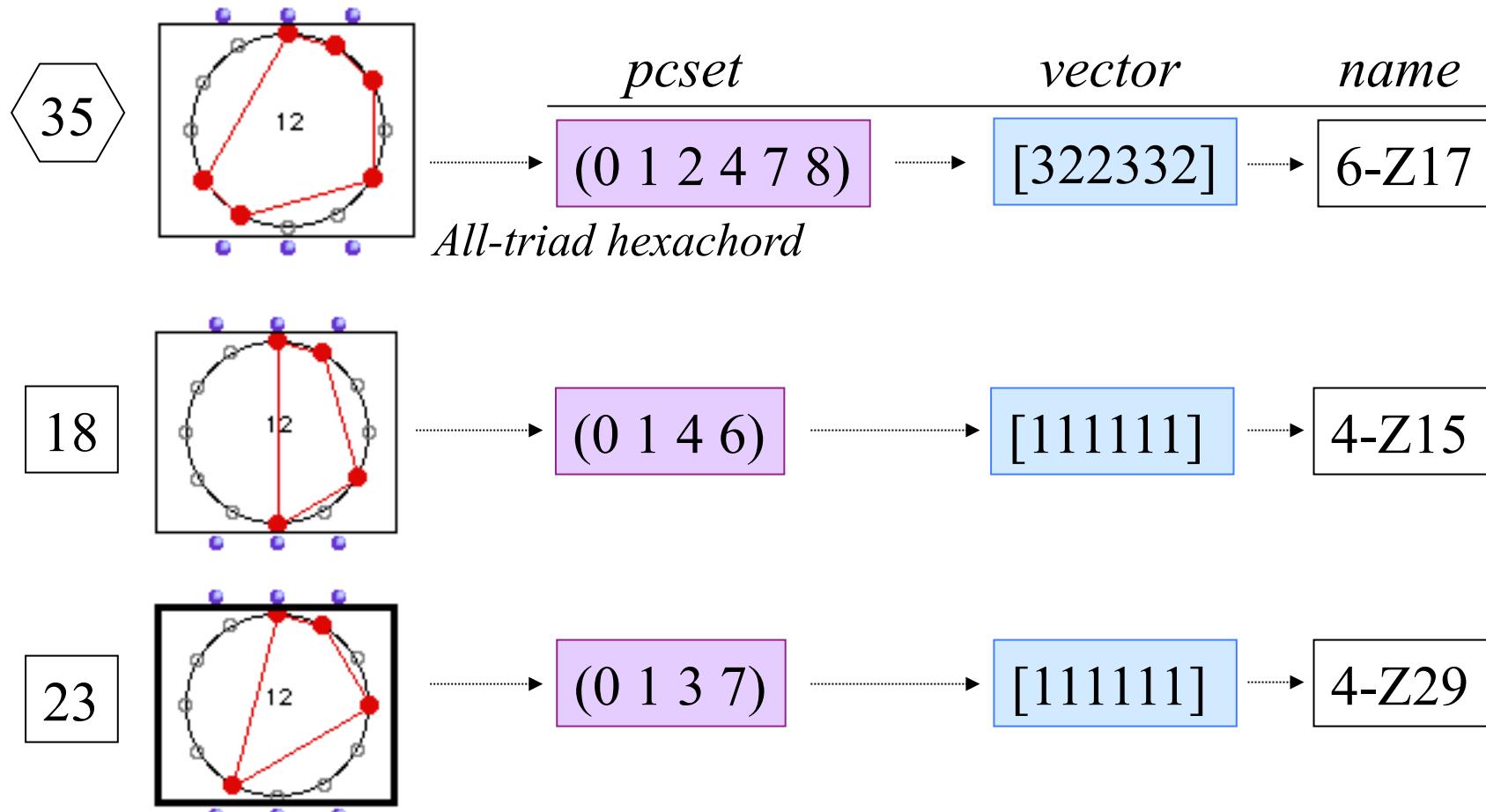
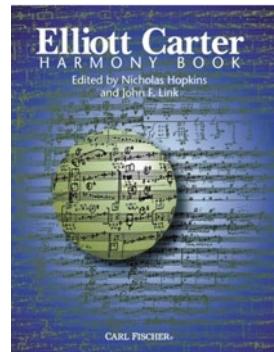
6-Z39 0,2,3,4,5,8
6-Z40 0,1,2,3,5,8
6-Z41 0,1,2,3,6,8
6-Z42(12) 0,1,2,3,6,9



5-Z12

Elliott Carter: 90+ (1994)

« From about 1990, I have reduced my vocabulary of chords more and more to the six note chord n° 35 and the four note chords n° 18 and 23, which encompass all the intervals » (Harmony Book, 2002, p. ix)



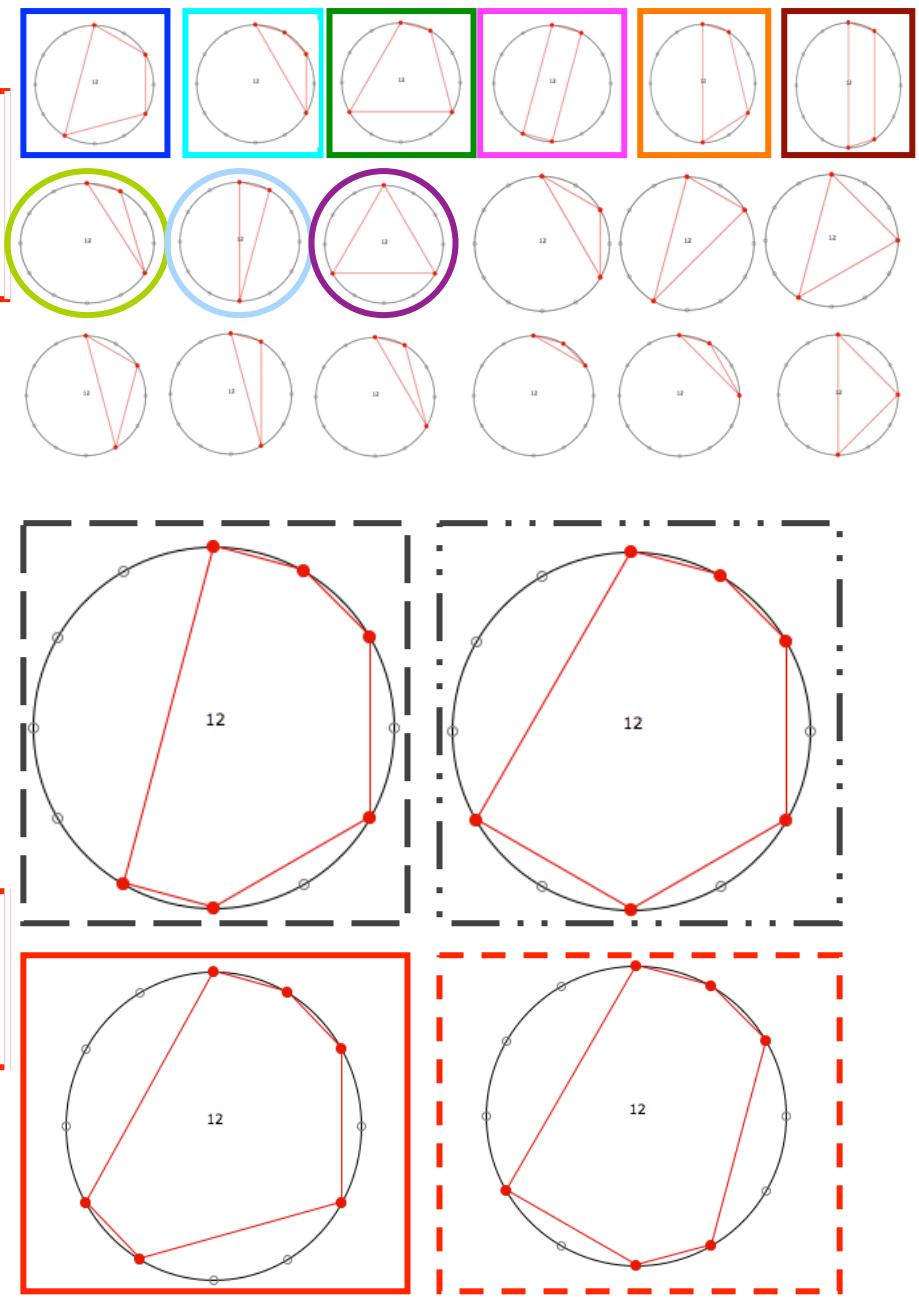
Elliott Carter : 90+ (1994) : combinatoire tetra/tricordale

mille e novanta auguri a caro Goffredo
90+

Piano

$\text{♩} = 96$

(senza pedale)*



Set Theory chez K. Stockhausen

Musical score for Set Theory, page 4, measures 4-8. The score is for two voices (Soprano and Bass) and includes dynamic markings (p, mf, f, mf, ff) and performance instructions (e.g., fingerings, grace notes). Measure 4 starts with a forte dynamic (f) in the bass. Measure 5 features a sustained note with a dynamic change from f to mf. Measure 6 shows a transition with dynamics p and ff. Measure 7 concludes with a dynamic ff.

Trois interprétations :



Henck



Kontarsky



Tudor

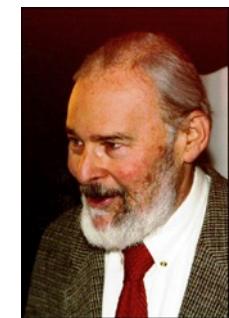
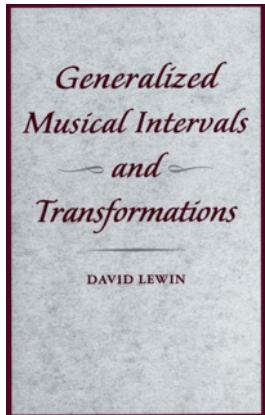
Musical score for Set Theory, page 5, measures 5-8. The score continues with dynamic changes and performance techniques. Measure 5 ends with a dynamic ff. Measure 6 begins with a dynamic p. Measure 7 features a dynamic ff. Measure 8 concludes with a dynamic f.



Musical score for Set Theory, page 11, measures 11-15. The score includes complex rhythmic patterns and dynamic markings such as ff and p. Measure 11 starts with a dynamic ff. Measure 12 features a dynamic p. Measure 13 shows a dynamic ff. Measure 14 concludes with a dynamic ff.

« Making and Using a Pcset Network for Stockhausen's Klavierstück III »

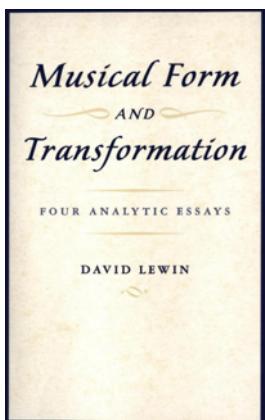
A musical score for Klavierstück III by Stockhausen. The score consists of two staves. The top staff has measures 4 through 8, with measure 4 in 4/4 and measures 5 through 8 in 5/8. The bottom staff has measures 3 through 8, with measure 3 in 3/4 and measures 4 through 8 in 8/8. Various dynamics like *p*, *mf*, and *f* are indicated. Three specific regions are highlighted with colored boxes: a red box covers measures 4-5 of the top staff, a green box covers measures 5-6 of the top staff, and a blue box covers measures 6-7 of the top staff. Below the score, three 12-note circles are shown, each with 12 dots around its circumference. Arrows from each highlighted region point to one of these circles, suggesting a mapping or analysis process.



D. Lewin
(1933-2003)

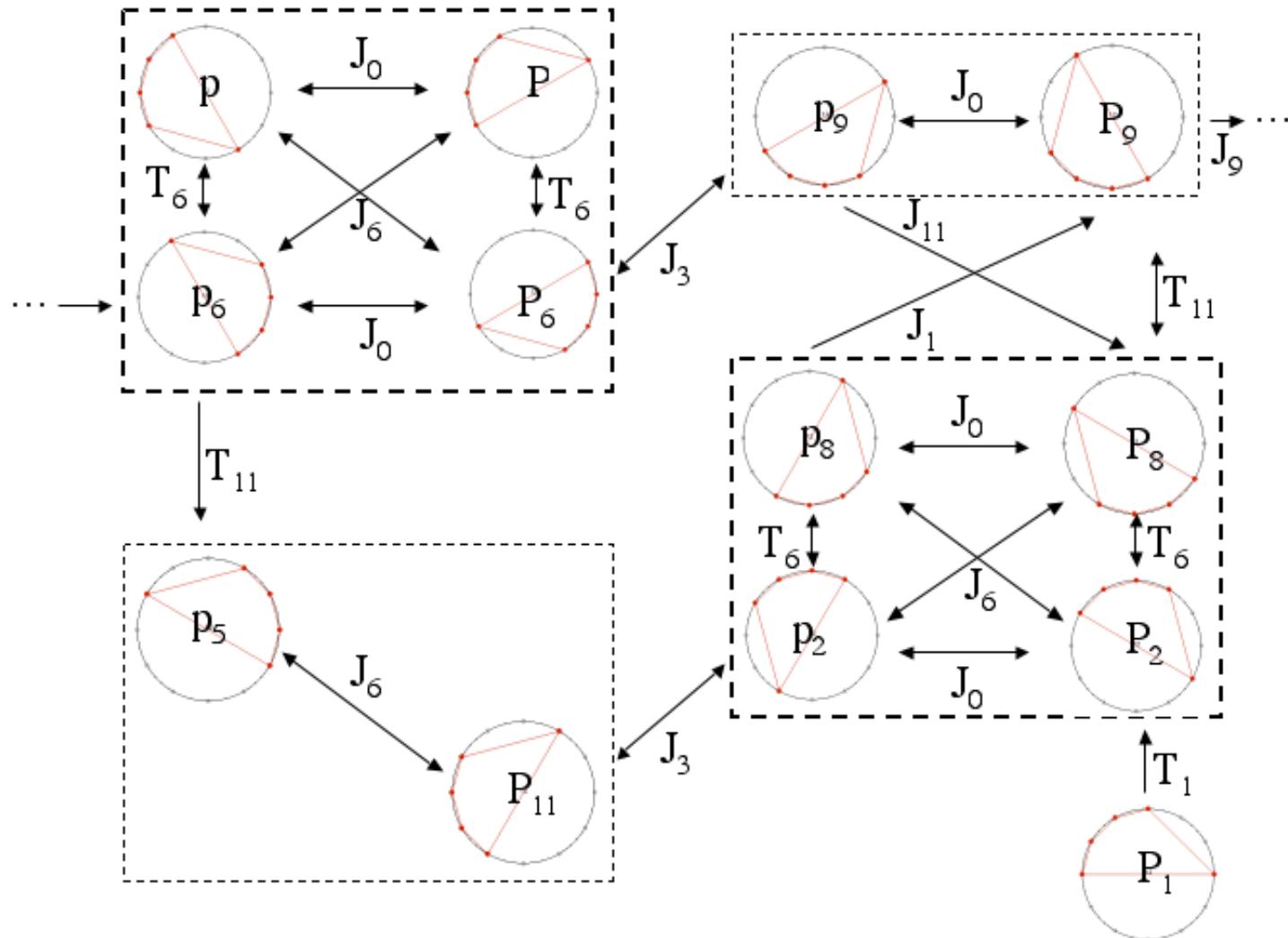
« The most ‘theoretical’ of the four essays, it focuses on the forms of one pentachord reasonably ubiquitous in the piece. A special **group of transformations** is developed, one suggested by the musical interrelations of the pentachord forms. Using that group, the essay arranges **all pentachord forms** of the music into a **spatial configuration** that illustrates network structure, for this particular phenomenon, over the entire piece. »

David Lewin, *Musical Form and Transformation*, YUP 1993



Reseau transformationnel

Stockhausen: *Klavierstück III* (Analyse de D. Lewin)



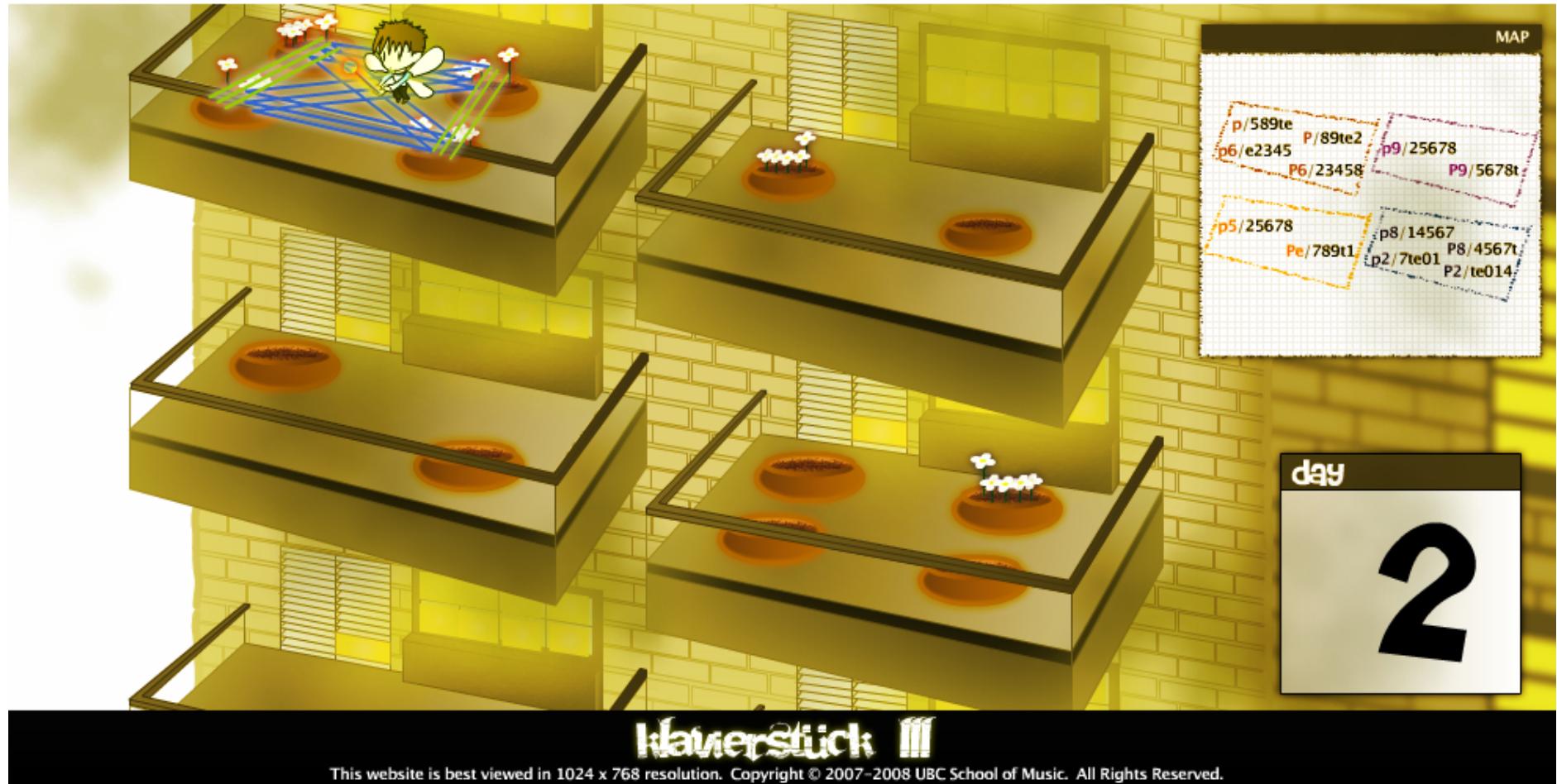
« Rather than asserting a network that follows pentachord relations one at a time, according to the chronology of the piece, I shall assert instead a network that displays all the pentachord forms used and all their **potentially functional interrelationships**, in a very compactly organized little **spatial configuration**. »

« [...] the sequence of events moves within a clearly defined world of possible relationships, and because - in so moving - **it makes the abstract space of such a world accessible to our sensibilities**. That is to say that the story projects what one would traditionally call *form*. »

Visualisations multimédia de l'analyse transformationnelle

R. Attas : Metaphors in Motion: Agents and Representation in Transformational Analysis, *MTO*, 15(1), 2009
<http://mto.societymusictheory.org/issues/mto.09.15.1/mto.09.15.1.attas.html>

Animation 1. Klavierstück III



Visualisations multimédia de l'analyse transformationnelle

R. Attas : Metaphors in Motion: Agents and Representation in Transformational Analysis, *MTO*, 15(1), 2009
<http://mto.societymusictheory.org/issues/mto.09.15.1/mto.09.15.1.attas.html>

Animation 2. Grow Your Own Pentachord

The screenshot shows a digital interface for creating a pentachord. At the top left is a "PLAYBACK SPEED" slider. In the center is a flower pot containing three small white flowers with yellow centers. To the left of the pot are two rows of wands: "T WANDS" with labels T1, T6, Te and "J WANDS" with labels J0, J1, J3, J6, J9, Je. Below the pot is a large, stylized letter "P" with the text "89te2" underneath it. To the right is a "PENTACHORD MAP" showing nodes p, P, p6, P6, p5, p8, and Te connected by arrows. A red dot labeled "You are here" is positioned on the map. At the bottom is a black bar with the text "grow your own pentachord!" and a note: "This website is best viewed in 1024 x 768 resolution. GROW YOUR OWN PENTACHORD! Copyright © 2007–2008 UBC School of Music. All Rights Reserved."

L'espace géométrique d'un *Prélude* de Chopin

Prelude 'Suffocation'

FREDERIC CHOPIN (1810-1849)
Op. 28, No. 4

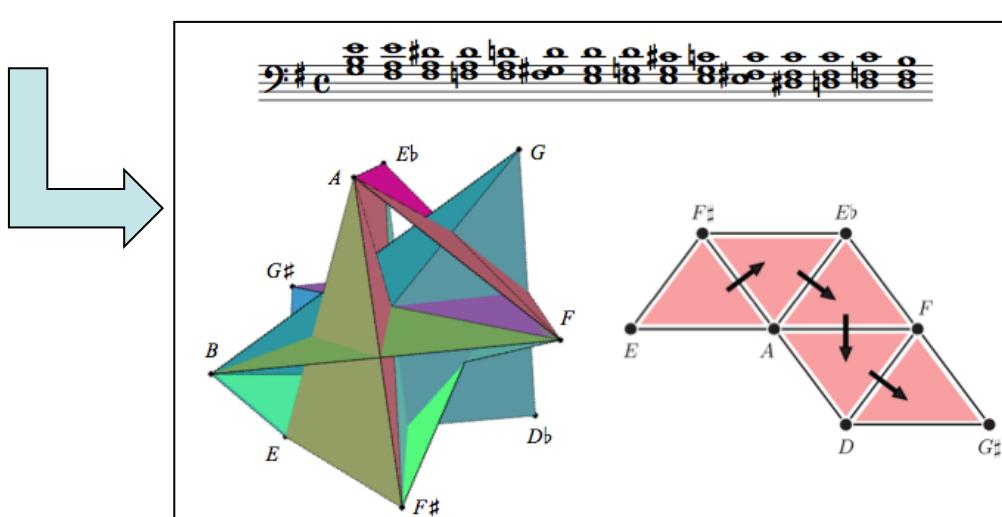
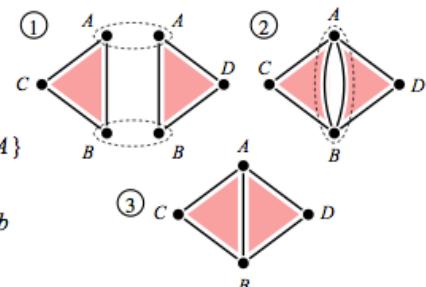
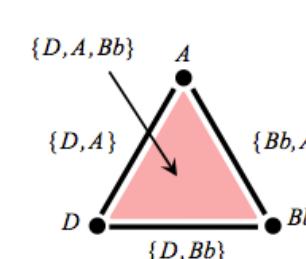
Largo



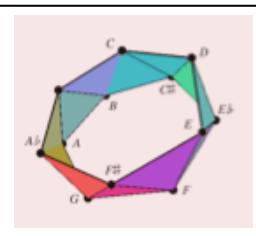
0-simplex

1-simplex

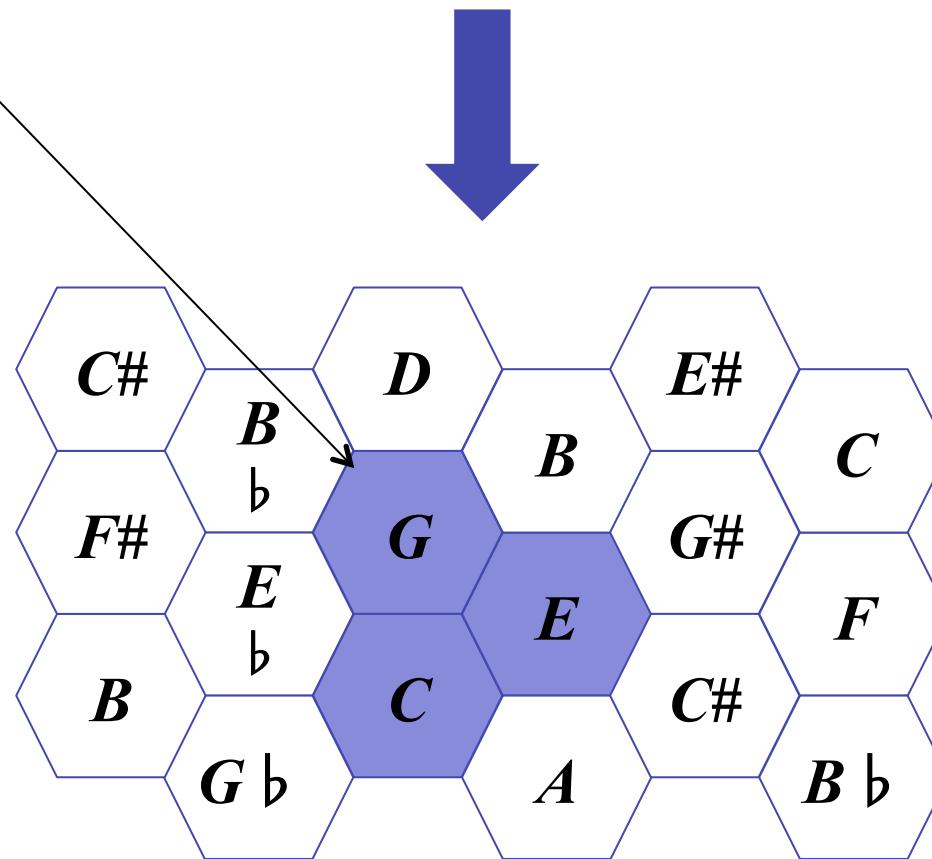
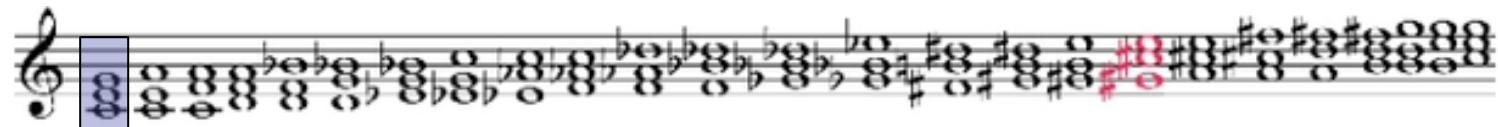
2-simplex



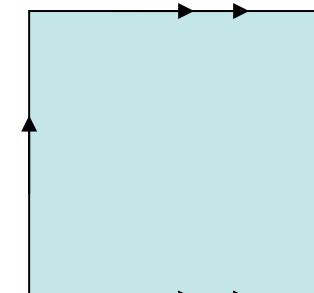
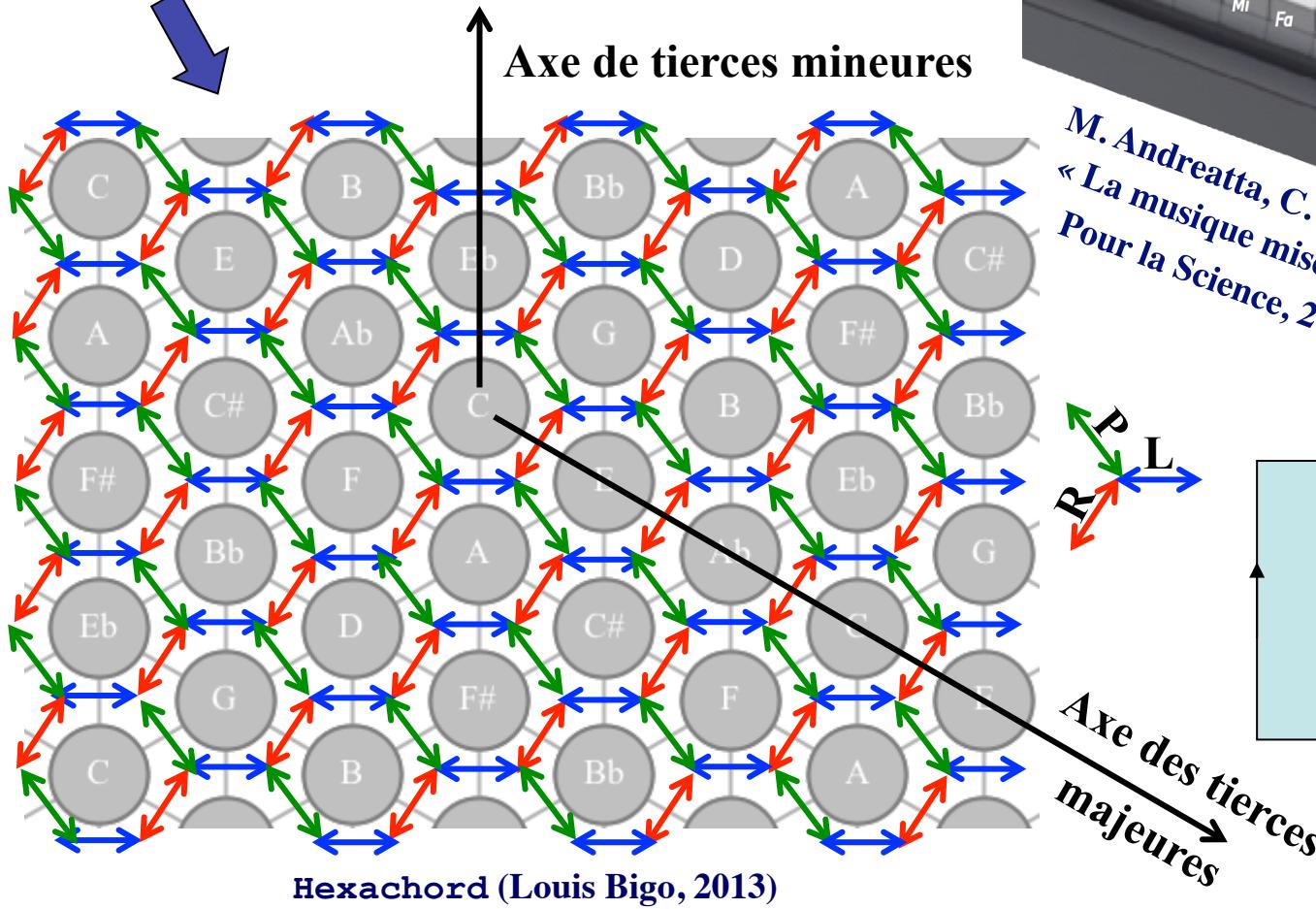
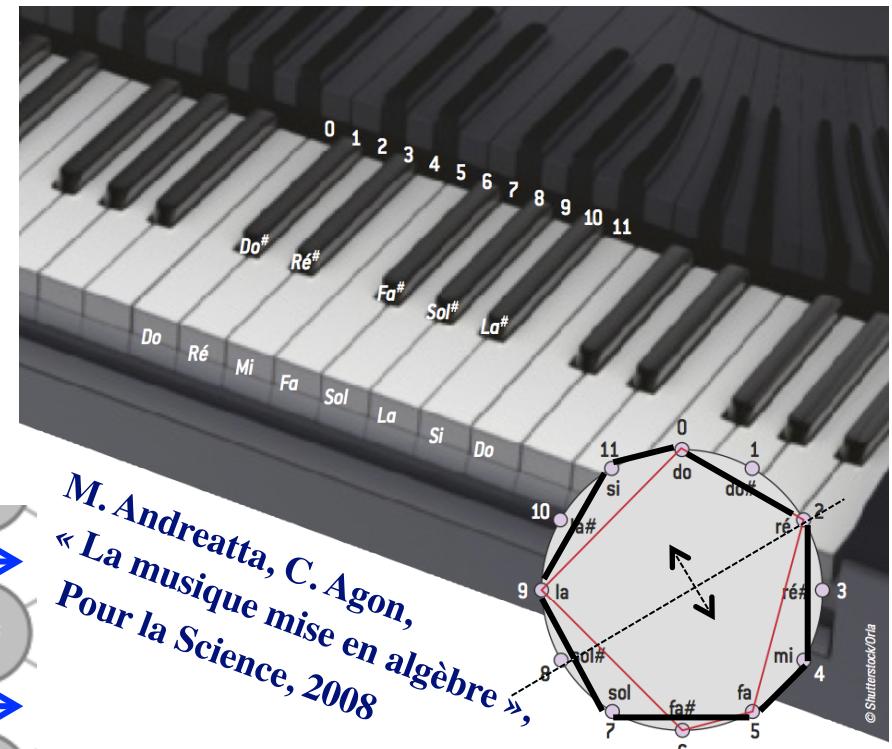
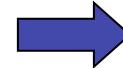
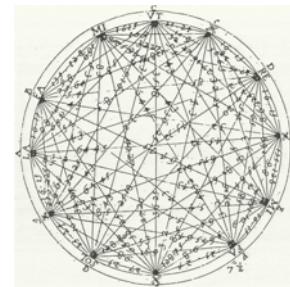
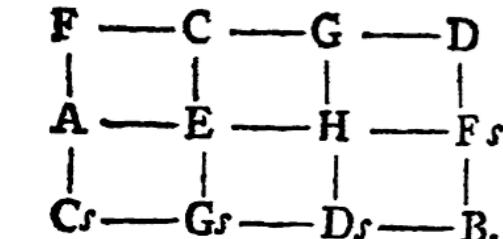
Louis Bigo, *Représentations symboliques musicales et calcul spatial*,
Thèse LAC/Ircam



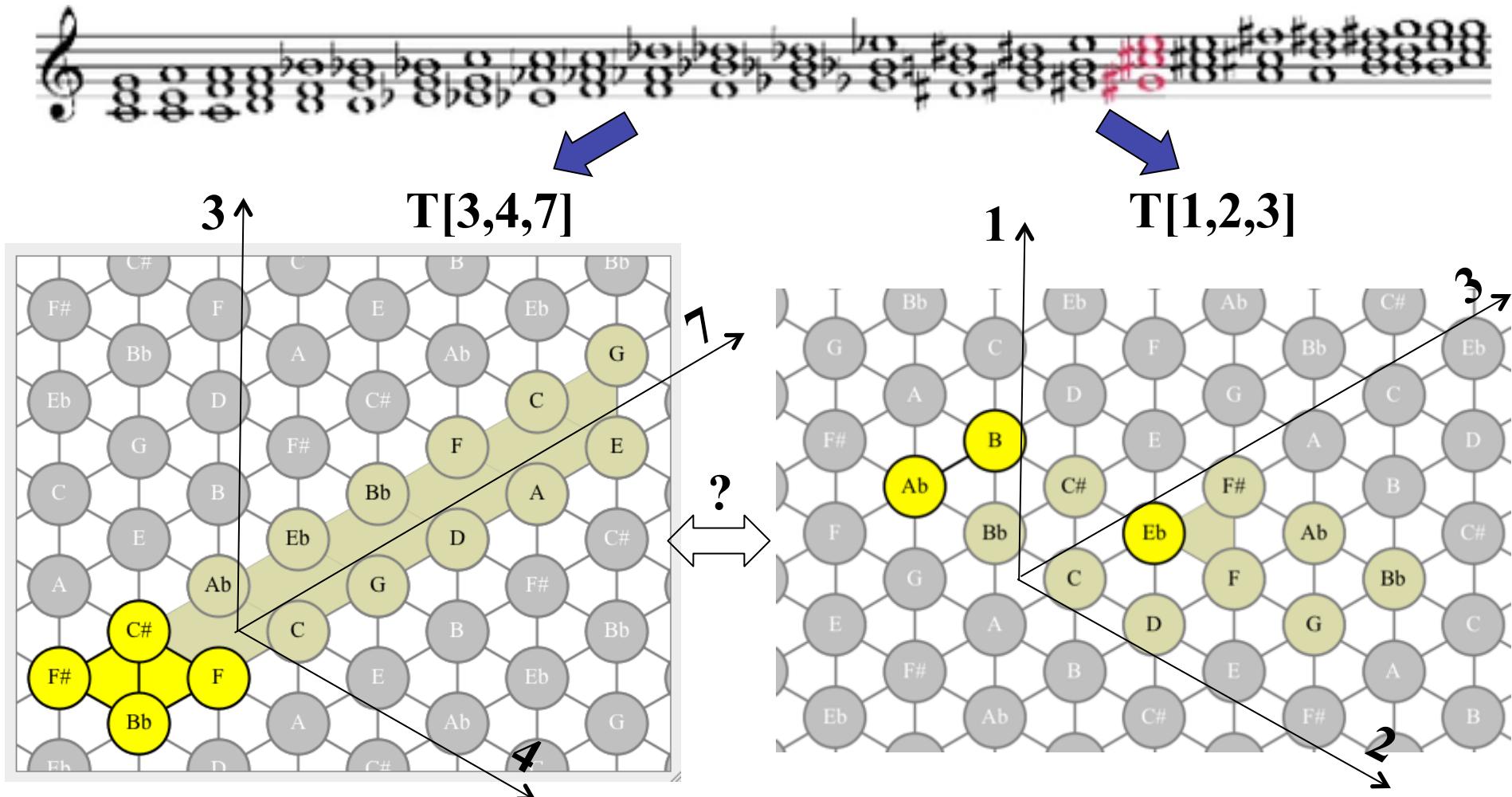
Extract of the 2nd movement of the Symphony No. 9 (L. van Beethoven)



Deux représentations équivalentes : le cercle et le tore



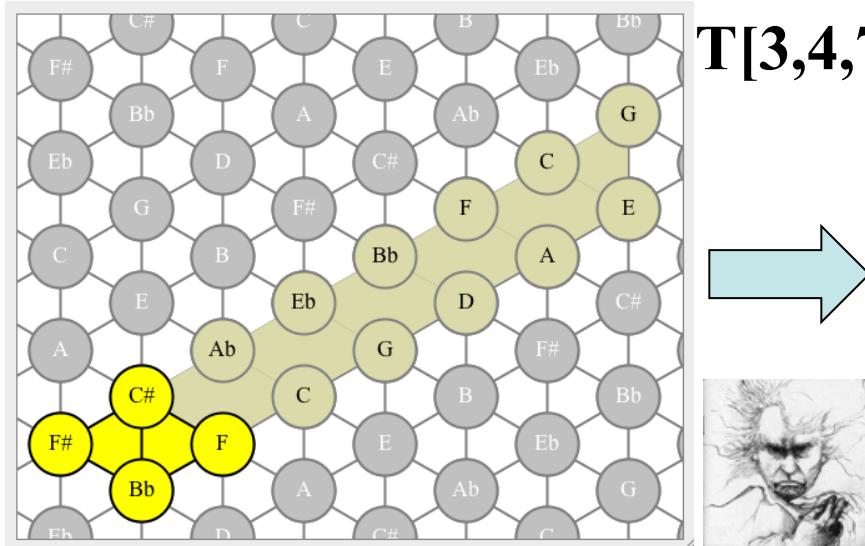
Le caractère spatial de la « logique musicale »



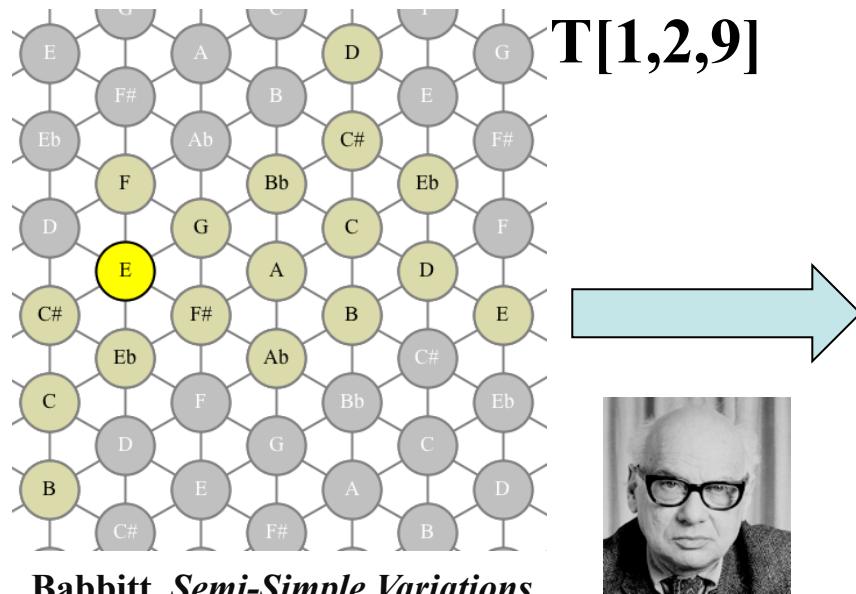
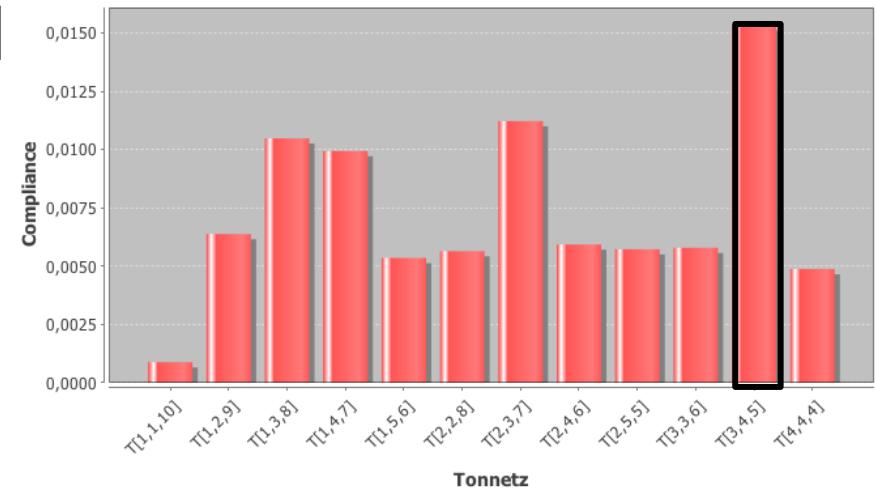
L. Bigo, M. Andreatta, J.-L. Giavitto, O. Michel, et A. Spicher, « Computation and Visualization of Musical Structures in Chord-based Simplicial Complexes », Proceedings Mathematics and Computation in Music Conference 2013 – Montreal, Springer



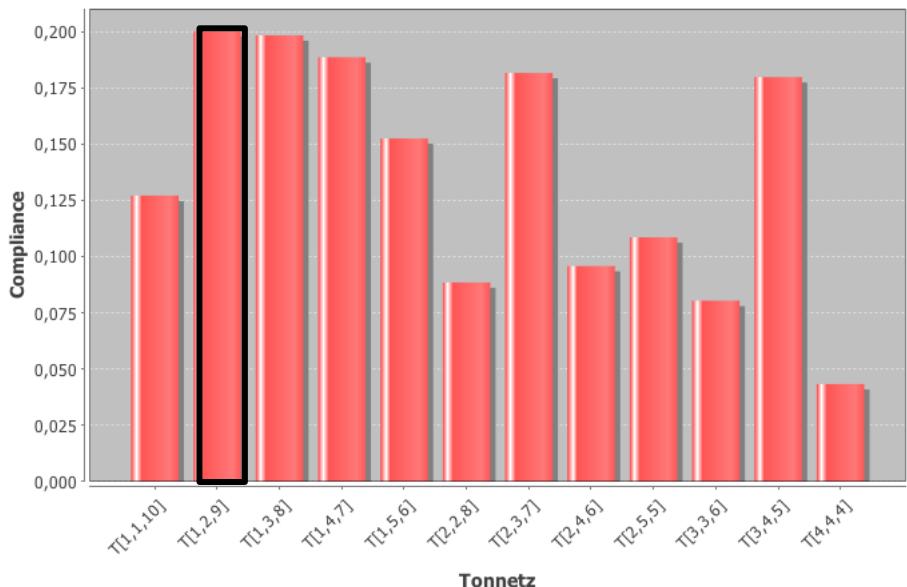
Le caractère spatial du « style musical »



Beethoven, 2^e mouvement de la 9^e Symphonie



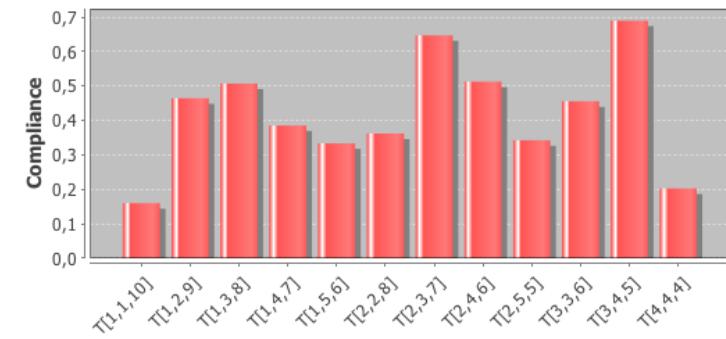
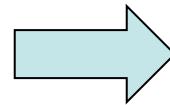
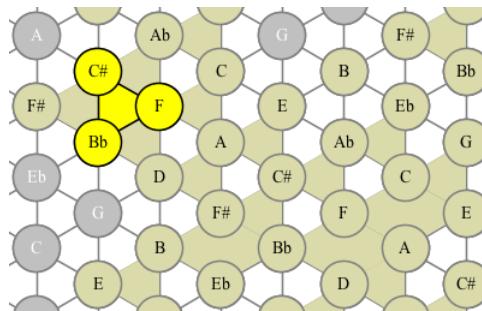
Babbitt, *Semi-Simple Variations*



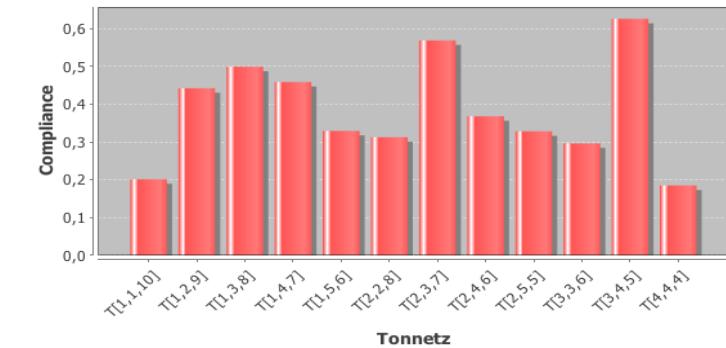
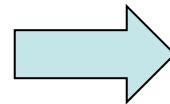
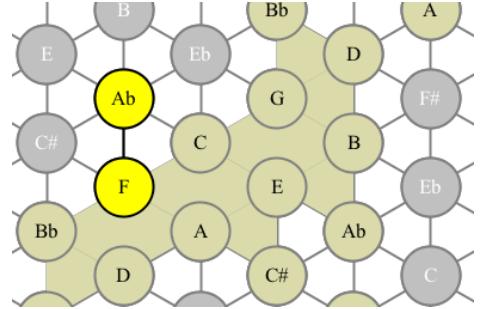
L'espace géométrique comme paramètre de style



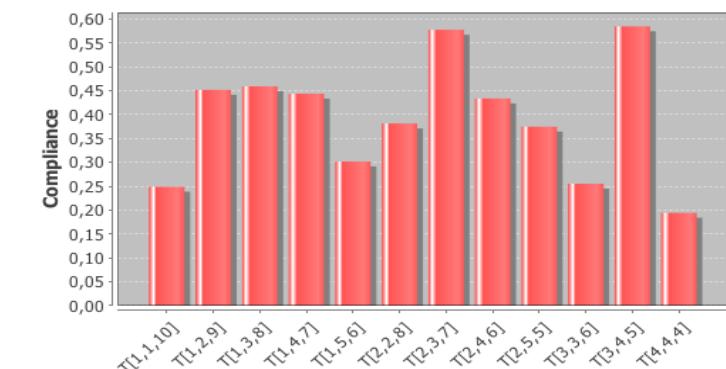
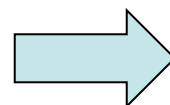
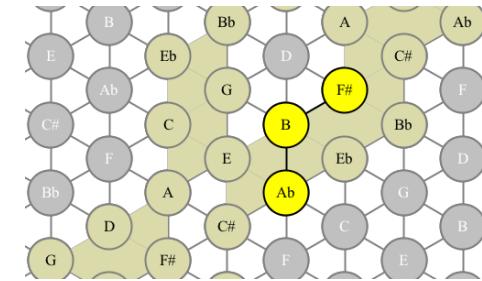
Thelonious Monk,
Brilliant Corners



Chick Corea,
Eternal Child



Bill Evans,
Turn Out the Stars

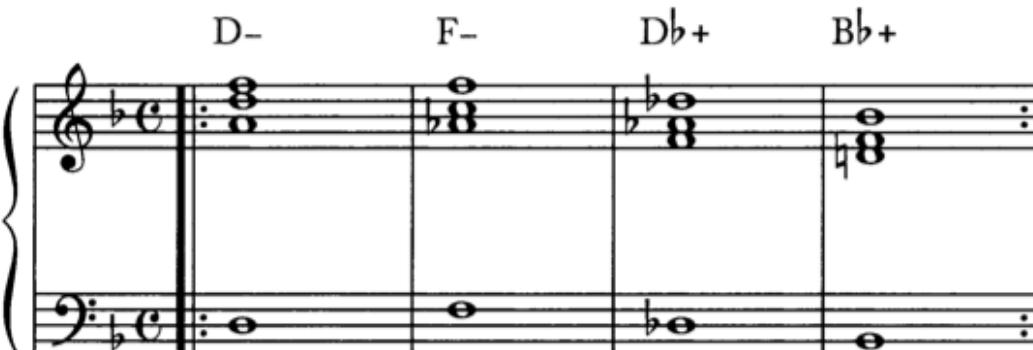


Mise en évidence des symétries dans la musica pop

- Guy Capuzzo, "Neo-Riemannian Theory and the Analysis of Pop-Rock Music", Music Theory Spectrum 26(2), p. 177-199, 2004

D- **F-** **D \flat +** **B \flat +**

Synthesizer {



*Shake the disease - 1985
(Depeche Mode) – min. 2'17"*

Red arrows point from the musical notation to two diagrams of the circle of fifths:

Dm **Fm**

Bb **D \flat**

The diagrams show the circle of fifths with pitch classes numbered 0 to 11. Blue lines connect the notes of the chords Dm, Fm, Bb, and D \flat . Red dashed arcs indicate specific intervals or connections between notes.

Below the diagrams is a large circular diagram representing the Mod-12 pitch class number (C = 0). It shows various chords and their relationships through blue arrows labeled L, R, P, and R. Shaded regions highlight specific chordal areas, and green arrows indicate modulations between different sets of chords.

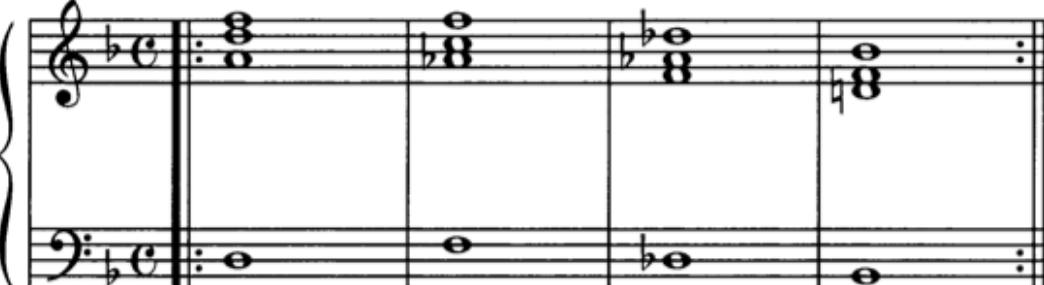
Major triad Minor triad

Mod-12 pitch class number (C = 0)

Trajectoire et progression harmonique dans le Tonnetz

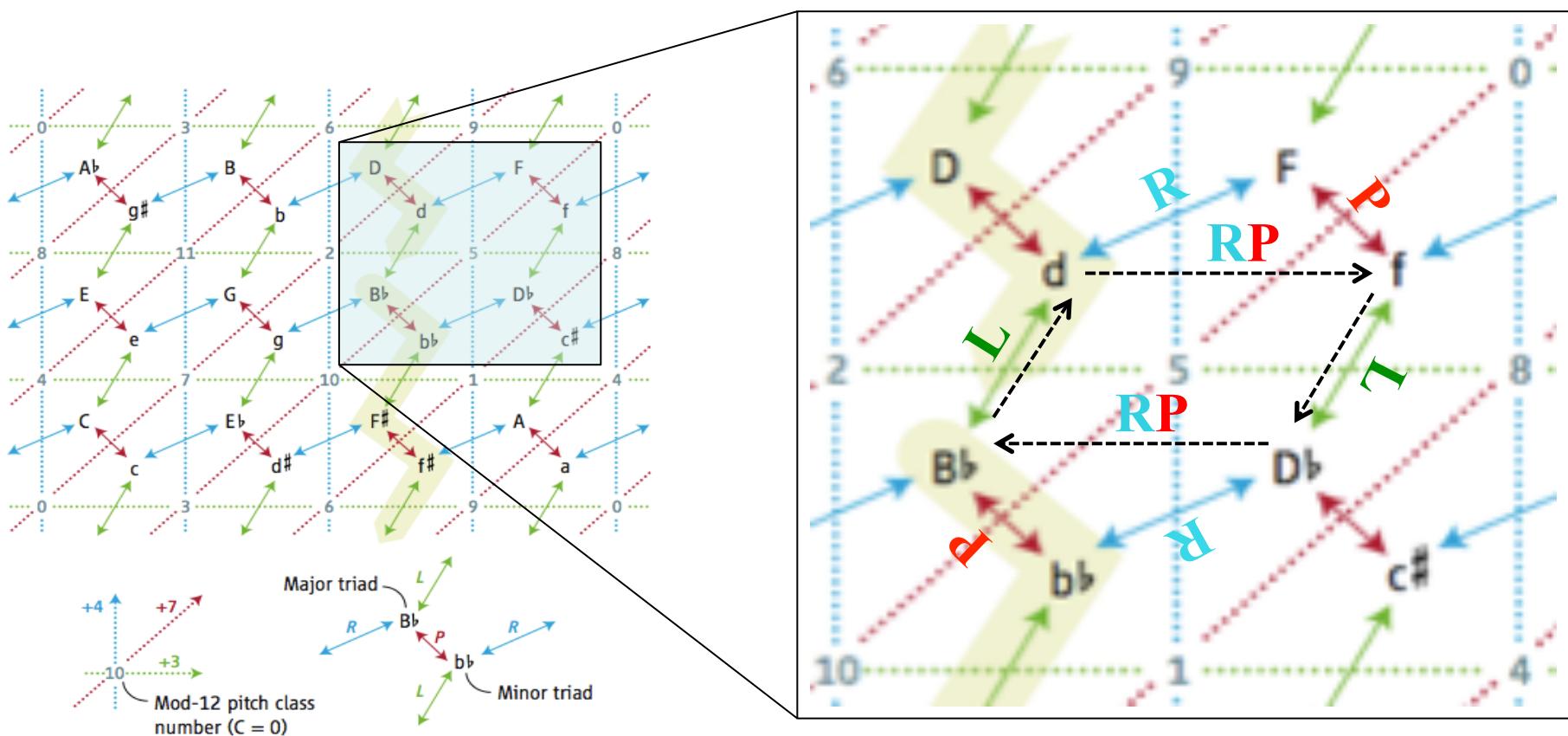
- Guy Capuzzo, "Neo-Riemannian Theory and the Analysis of Pop-Rock Music", Music Theory Spectrum 26(2), p. 177-199, 2004

D- $\xleftarrow{\text{RP}}$ F- $\xleftarrow{\text{L}}$ D \flat + $\xleftarrow{\text{RP}}$ B \flat + $\xleftarrow{\text{L}}$



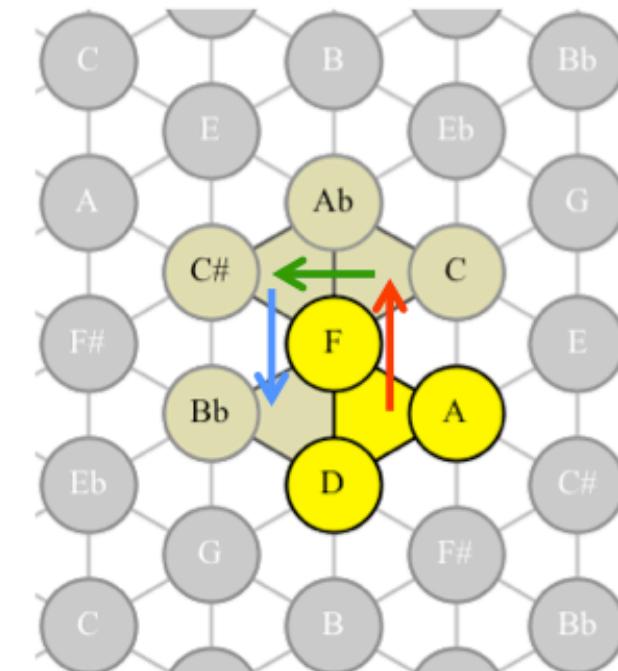
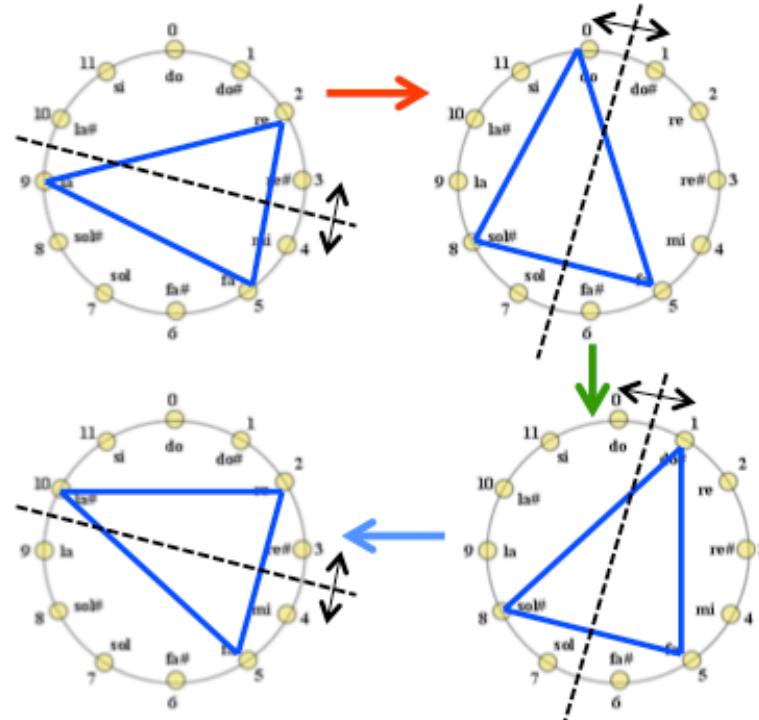
*Shake the disease - 1985
(Depeche Mode)*

Séquence RPLRPL



Mise en évidence des symétries dans la musica pop

- Guy Capuzzo, "Neo-Riemannian Theory and the Analysis of Pop-Rock Music", Music Theory Spectrum 26(2), p. 177-199, 2004



→ Hexachord (by Louis Bigo, 2013)

Progressions harmoniques chez Zappa: où sont les symétries ?

- Guy Capuzzo, "Neo-Riemannian Theory and the Analysis of Pop-Rock Music", Music Theory Spectrum 26(2), p. 177-199, 2004

The musical score shows two staves. The top staff is for 'Synthesizer' and the bottom staff is for piano. The piano part features a complex sequence of chords and notes. A green dashed box highlights a section from the piano staff, labeled 'Fine'. This section includes chords like F+, A-, Ab+, G+, D+, F#-, F+, E+, and E-. The score concludes with 'D.C. al Fine'.

Synthesizer:

- Chords: G+, A+
- Notes: 5, 3, 6, 4, 5, 3, 5, 3, 6, 4, 5

Piano (highlighted section):

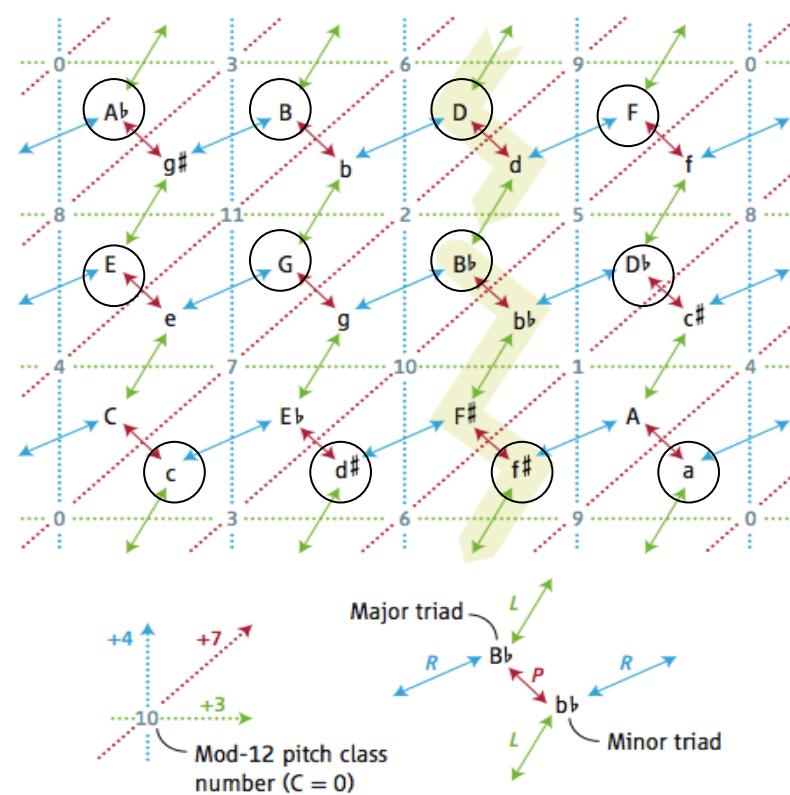
- Chords: F+, A-, Ab+, G+, D+, F#-, F+, E+, E-
- Notes: B+, D#, D+, C#, Ab+, C-, B+, Bb+, E+, B+, F#-, C#, F#+, A+, E+, E-

Conclusion: D.C. al Fine

« Easy Meat » - 1981 (Frank Zappa)



(min. 2'29")



La cellule génératrice et ses translations spatiales

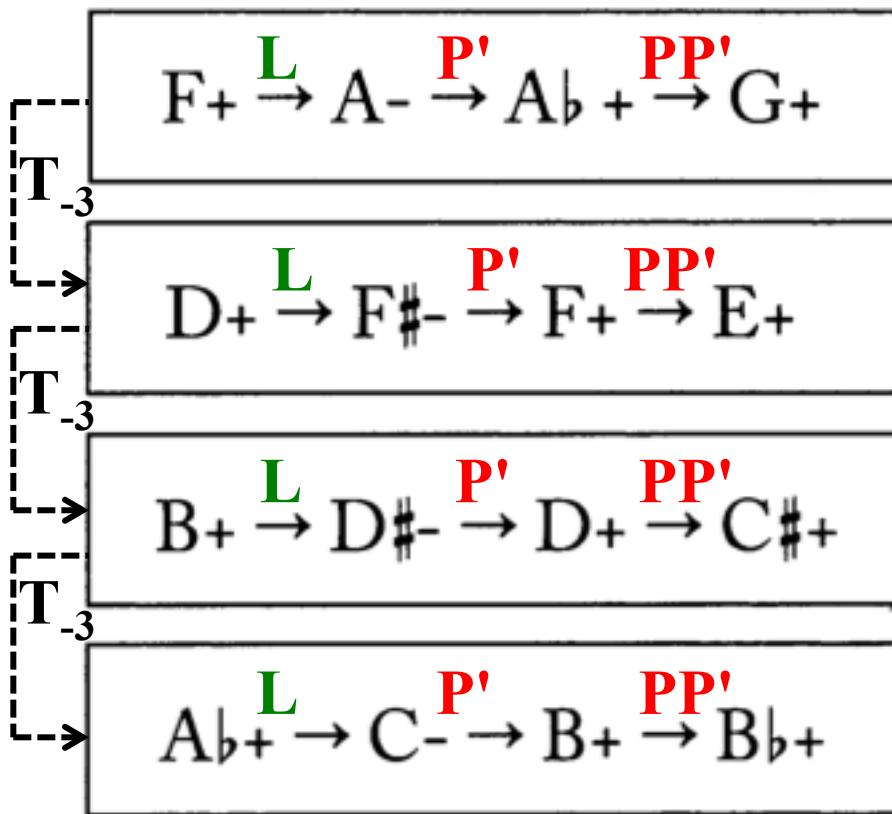
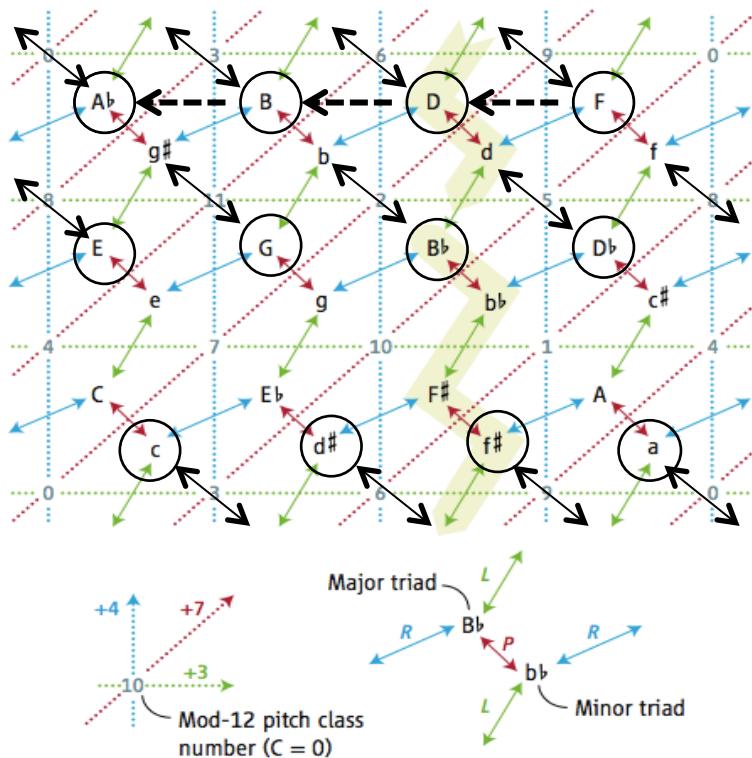
- Guy Capuzzo, "Neo-Riemannian Theory and the Analysis of Pop-Rock Music", Music Theory Spectrum 26(2), p. 177-199, 2004

Synthesizer

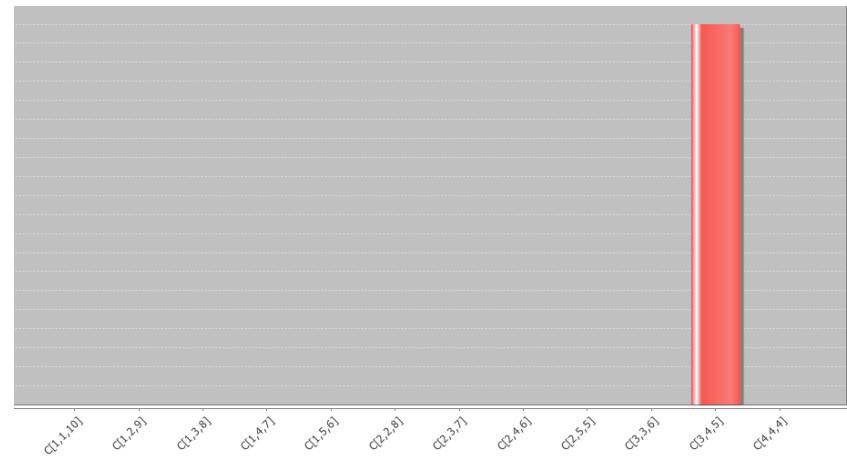
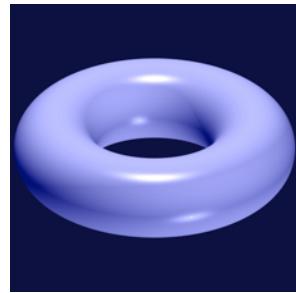
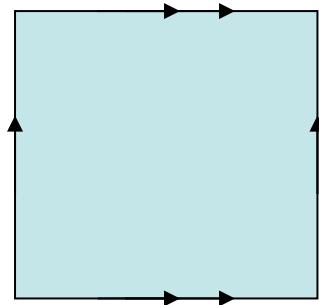
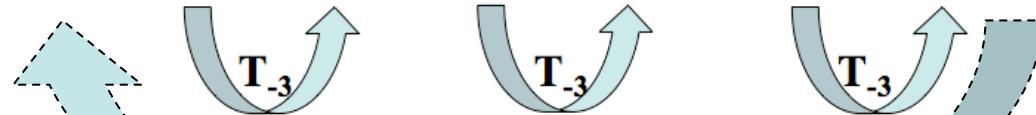
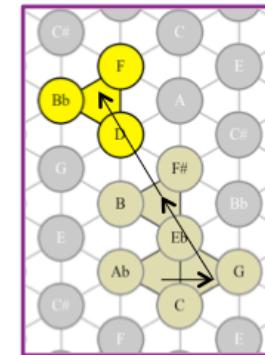
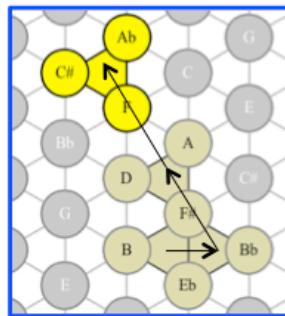
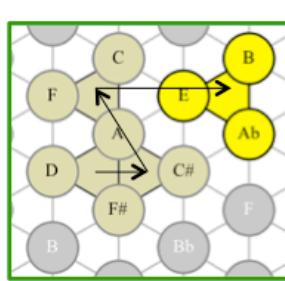
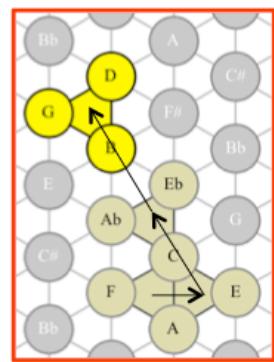
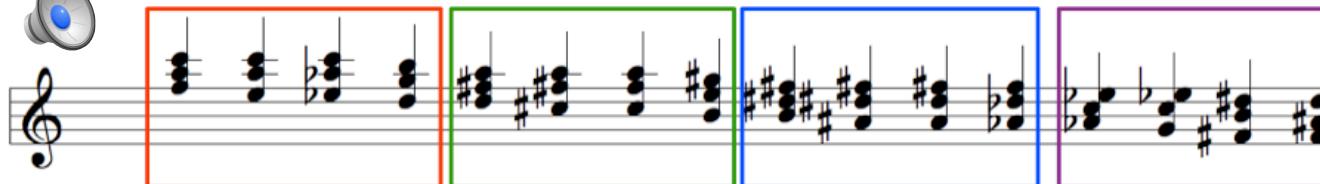
Fine

D.C. al Fine

« Easy Meat » - 1981 (Frank Zappa)



L'espace (de la progression harmonique)



Progressions harmoniques dans « Madeleine » (Paolo Conte)

Preludio *Moderato*

(pf) (s)

Chorus

Lab Ré/Fa Sib⁷ Mi^b/Ré Si/Ré# Mi Do# Fa#

Qui, Ré/Fa Sib⁷ Mi^b/Ré Si/Ré# Mi Do# Fa#

Tan - to io ca - pi - sco sol : tut - to il meglio è già qui, non ci so - no pa

[Ma] qual - che vol - ta è co : io ca - pi - sco sol : tan - to il tat - to del - le tue

(ct) (ct) (ct)

Re/La Sol Mi⁷ La⁷ Re Lab⁷ Ré Do⁷ Mi^b

ro - le per spie ga re ed in - tui - re e ca - pi - re, Ma de - leine, e se mai ri - cor da-re... Mi^b

ma - ni na - to e la can - zo - ne per - du - ta, e ri - tro - va - ta, come un' al - tra un' al - tra vi - ta...

(ct) (ct) (ct)



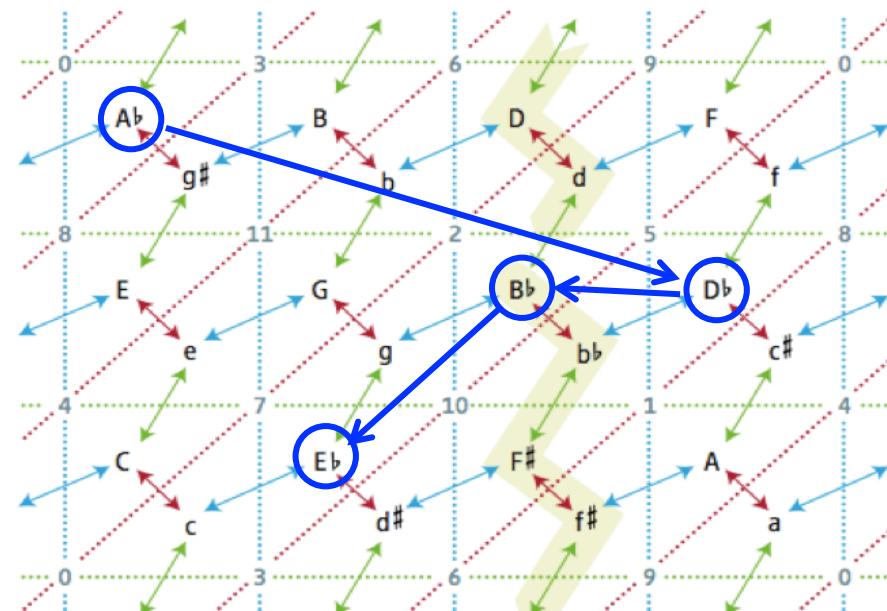
S. La Via, *Poesia per musica e musica per poesia.*
Dai trovatori a Paolo Conte, Carocci, 2006

→ **Lab → Réb/Fa → Sib⁷ → Mib⁷/Réb**

→ **Si/Ré# → Mi → Do# → Fa#**

→ **Ré/La → Sol → Mi⁷ → La⁷**

→ **Ré → Lab⁷ → Réb → Do⁷ → Mib**



Progressions harmoniques dans « Madeleine » (Paolo Conte)

Prelude *Moderato*

Chorus

Lab → Réb/Fa → Sib⁷ → Mib⁷/Réb

Qui, tut - to il meglio è già
io ca - pi - sco sol : tan to
qui, non ci so - no pa
il tat - to del - le tue
che qual - cu - no_è tor

Re/La Sol Mi⁷ La⁷ Re Lab⁷ Réb Do⁷ Mi⁷

ro - le per spie ga re ed in - tui - re e ca - pi - re, Ma de - leine, e se mai ri-cor da-re...
ma - ni na - to e la can - zo - ne per - du - ta, come un' al - tra un' al - tra vi-ta...

ma - ni na - to e la can - zo - ne per - du - ta, come un' al - tra un' al - tra vi-ta...



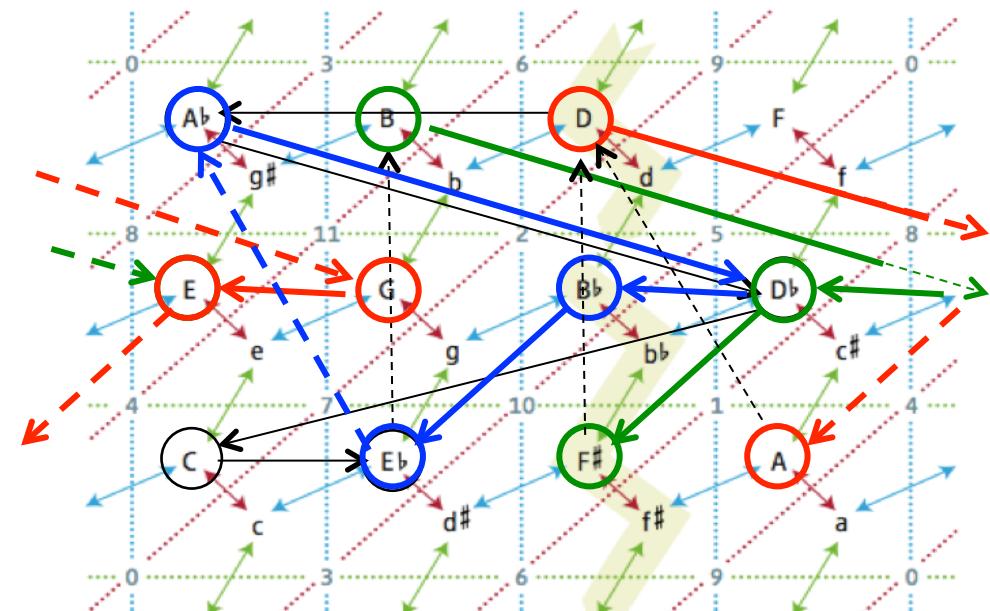
S. La Via, *Poesia per musica e musica per poesia.*
Dai trovatori a Paolo Conte, Carocci, 2006

→ Lab → Réb/Fa → Sib⁷ → Mib⁷/Réb

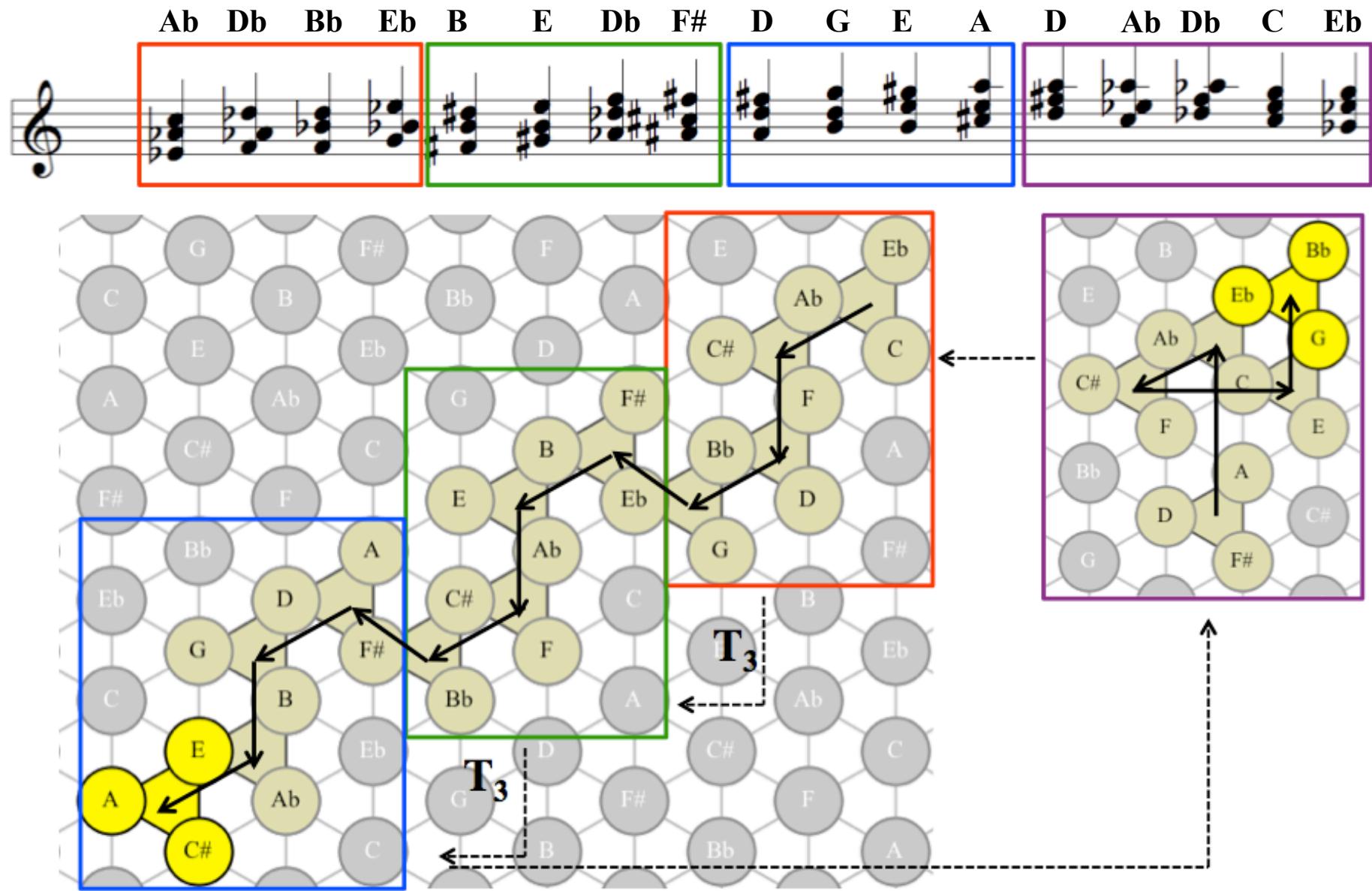
→ Si/Ré# → Mi → Do# → Fa#

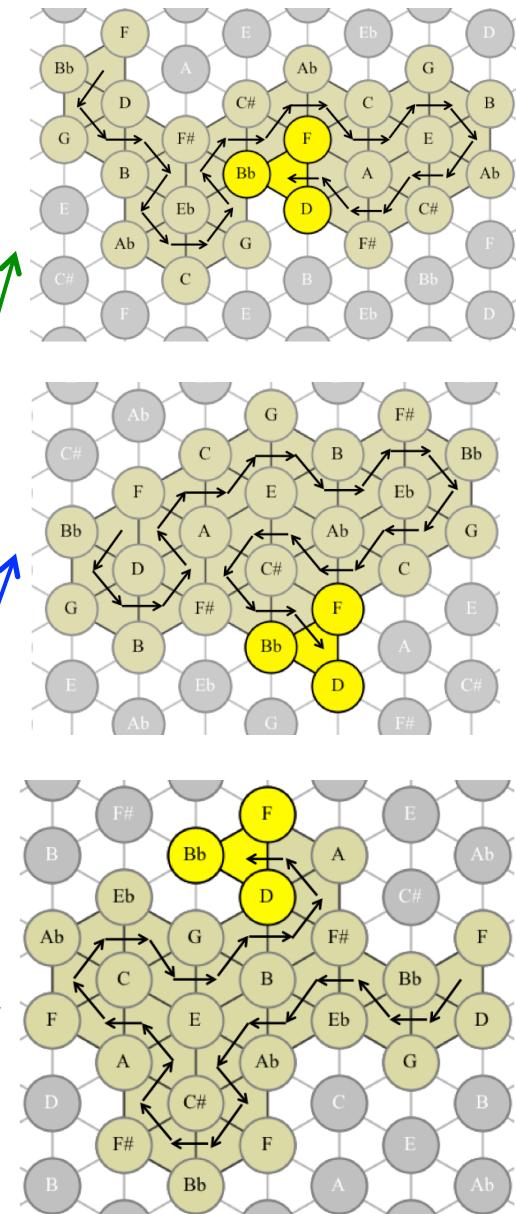
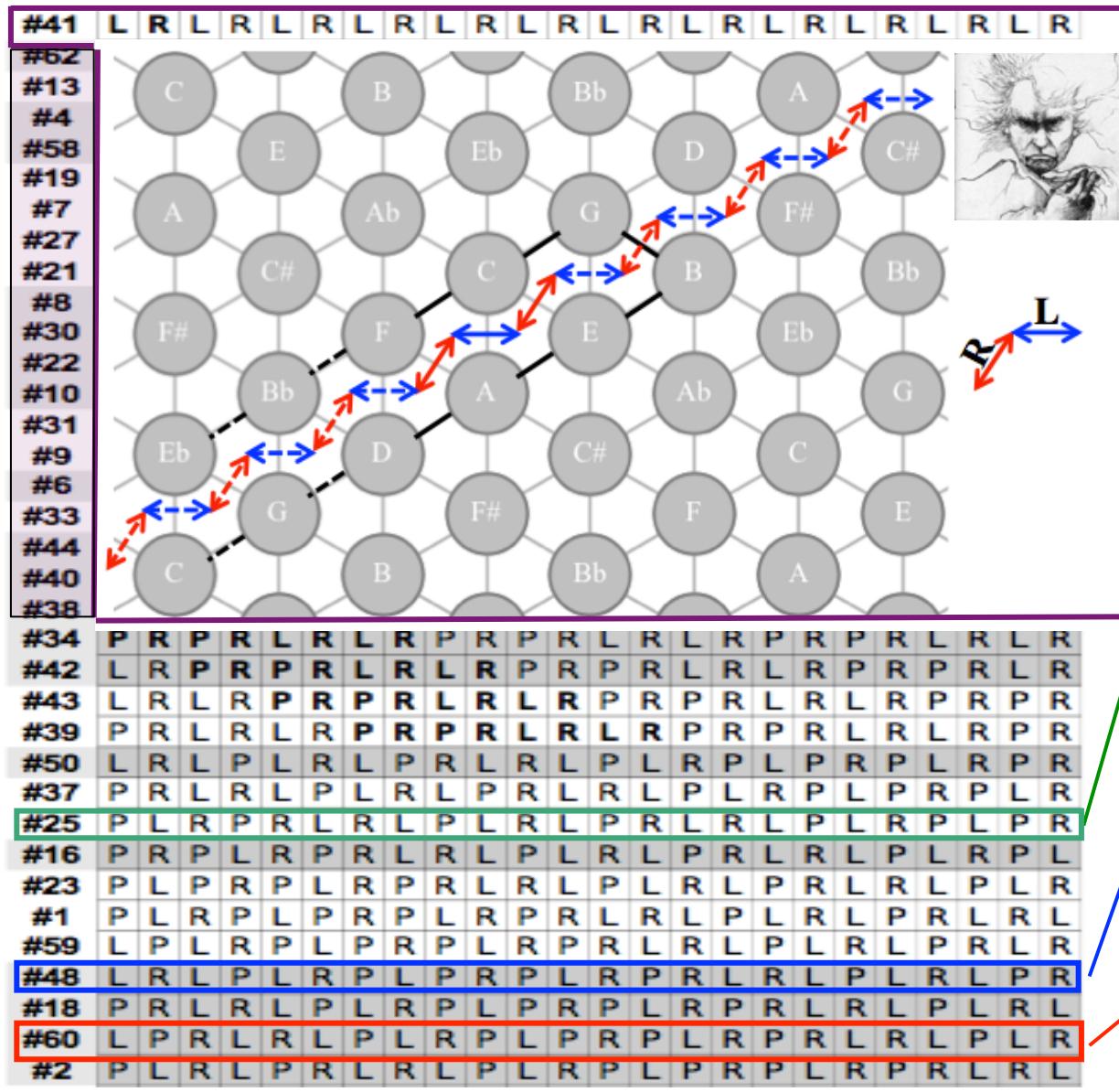
→ Ré/La → Sol → Mi⁷ → La⁷

→ Ré → Lab⁷ → Réb → Do⁷ → Mib



La trajectoire spatiale de « Madeleine » et son caractère ‘hamiltonien’





Aprile, chanson hamiltonienne « décadente »

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

mi_m→Sol→si_m→Ré→ré_m→Sib→sol_m→Mib→mib_m→Si→sol#_m→Mi

(Gabriele d'Annunzio)

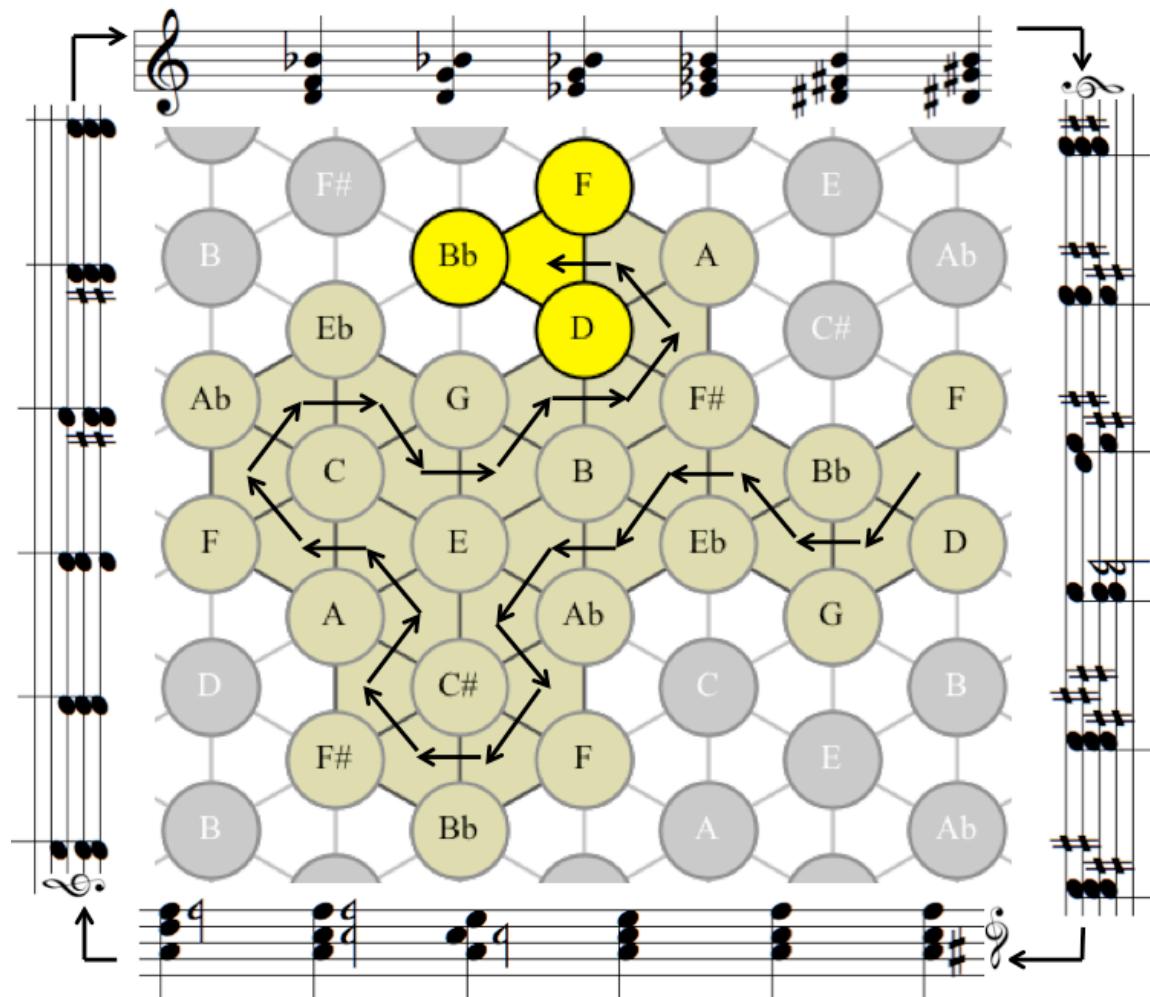
Socchiusa è la finestra, sul giardino.
Un'ora passa lenta, sonnolenta.
Ed ella, ch'era attenta, s'addormenta
a quella voce che già si lamenta,
- che si lamenta in fondo a quel giardino.

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.

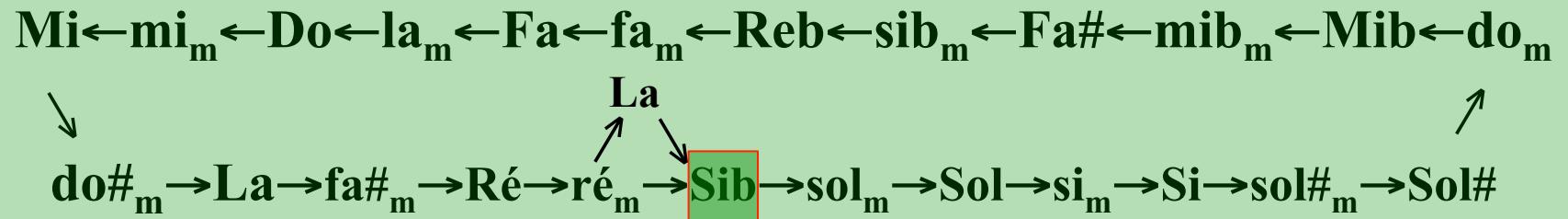
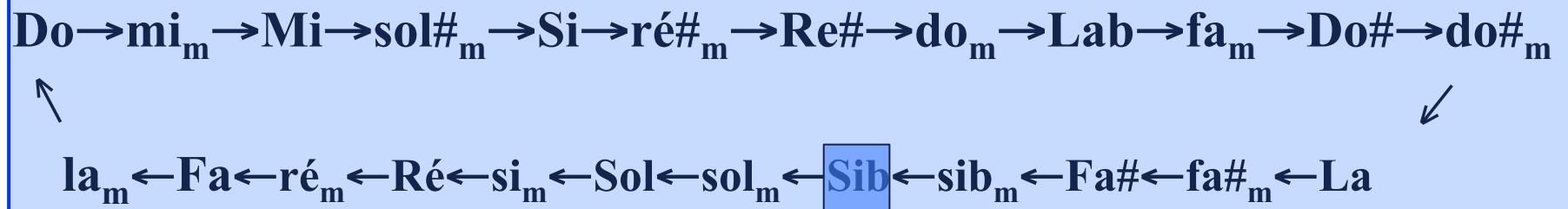
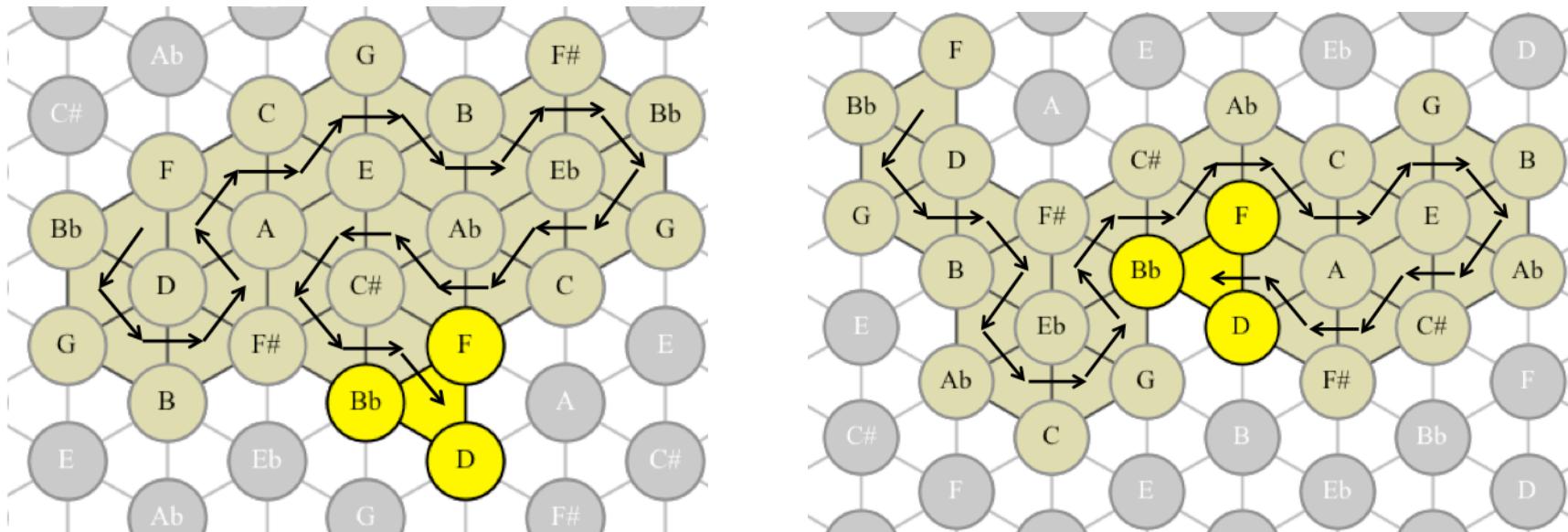
Ella stende l'angoscia sua nel sonno.
L'angoscia è forte, e il sonno è così lieve!
(Par la luce d'aprile quasi una neve
che sia tiepida.) Ed ella certo deve
soffrire, vagamente, anche nel sonno.



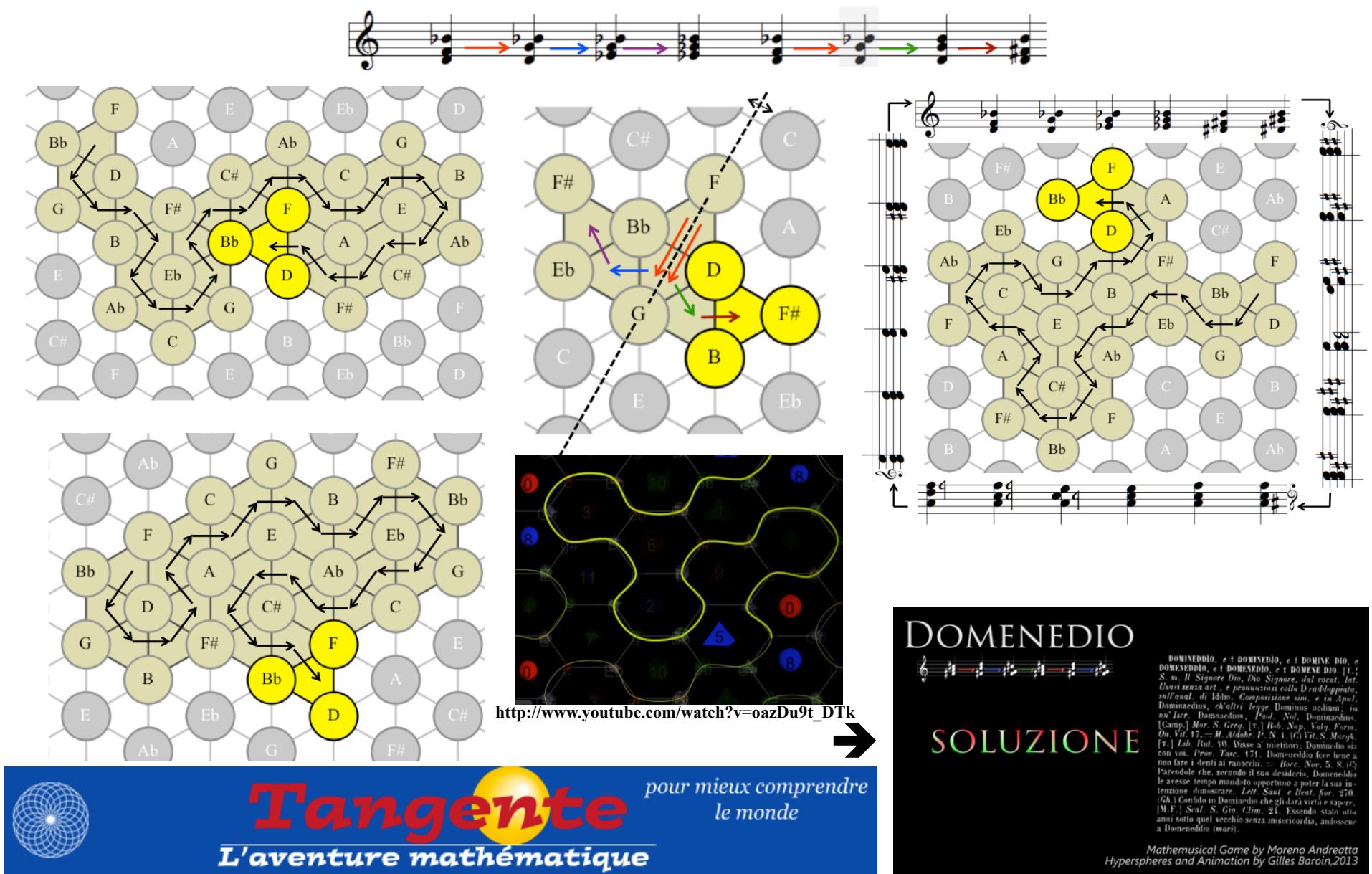
Gabriele D'Annunzio (1863-1938)



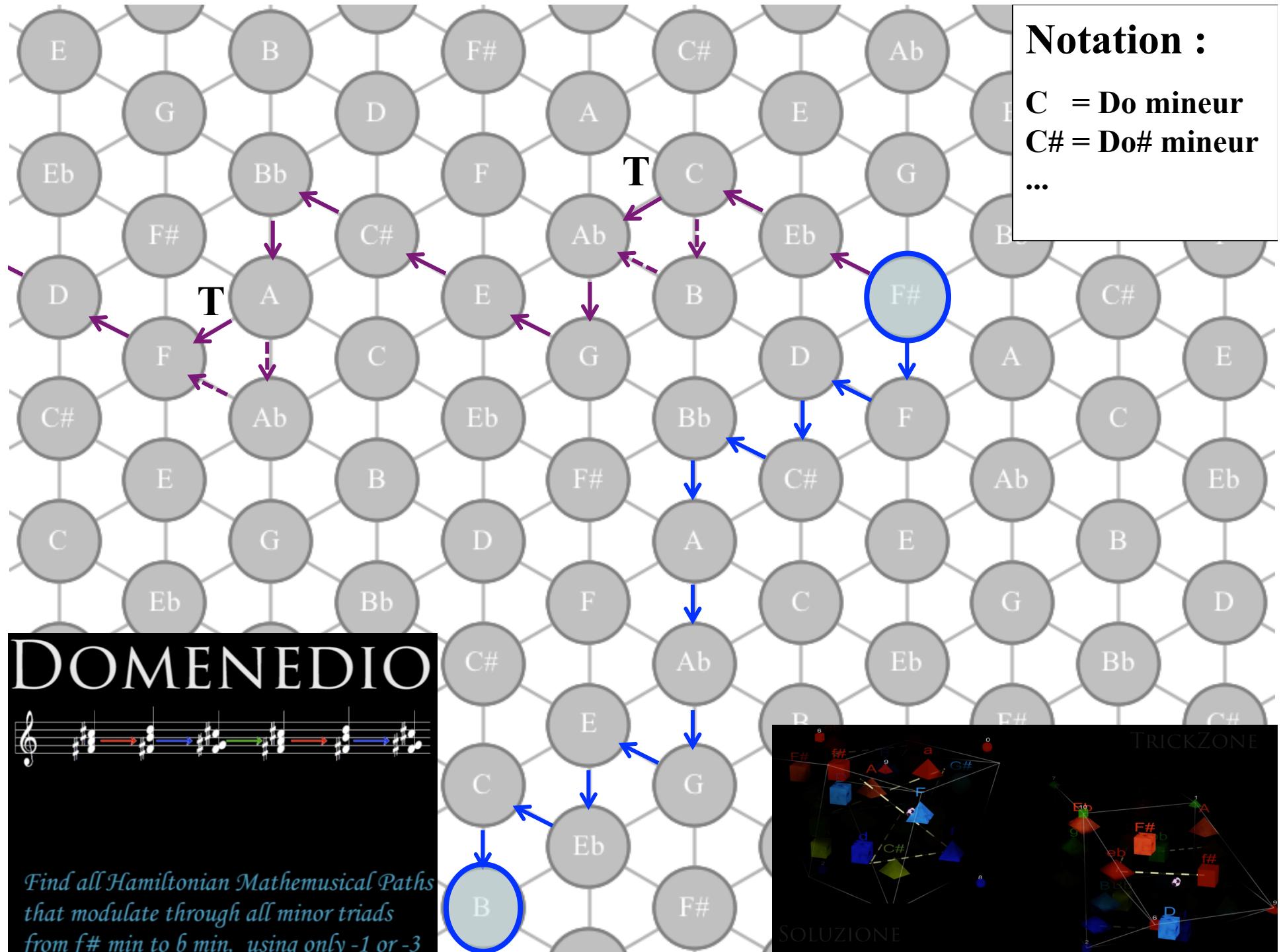
Deuxième et troisième cycle hamiltonien



Maths et expériences oumu(po)piennes



M. Andreatta, « Math'n pop : symétries et cycles hamiltoniens en chanson », *Tangente*, (à paraître)



Notation :

C = Do mineur

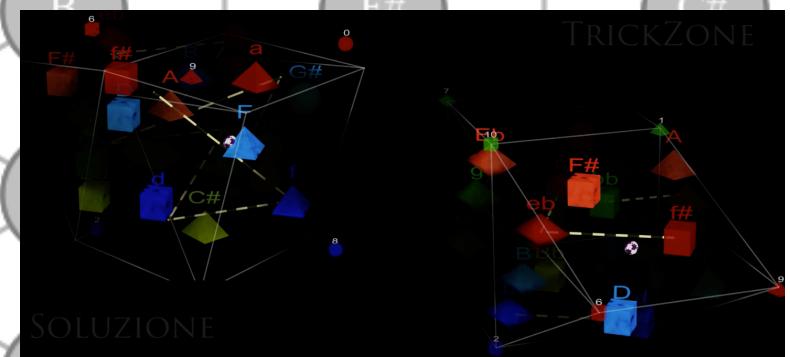
C# = Do# mineur

1

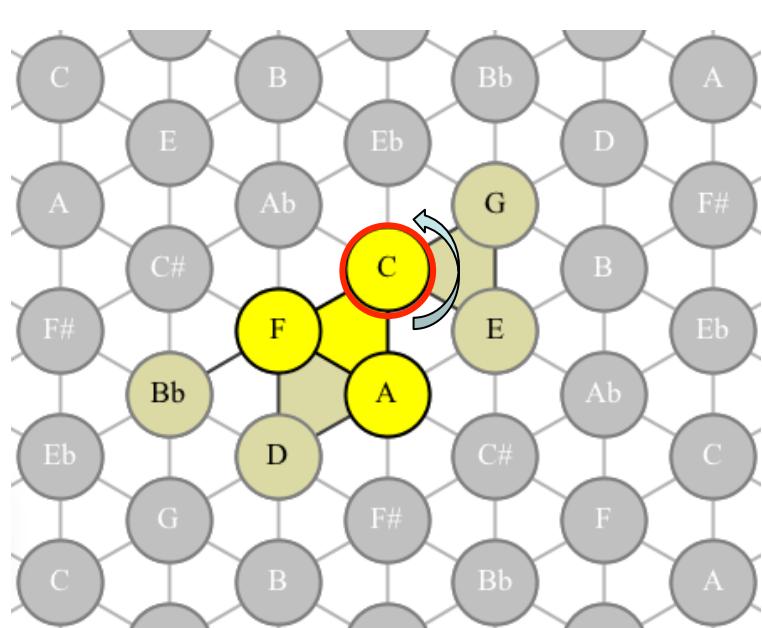
DOMENEDIO



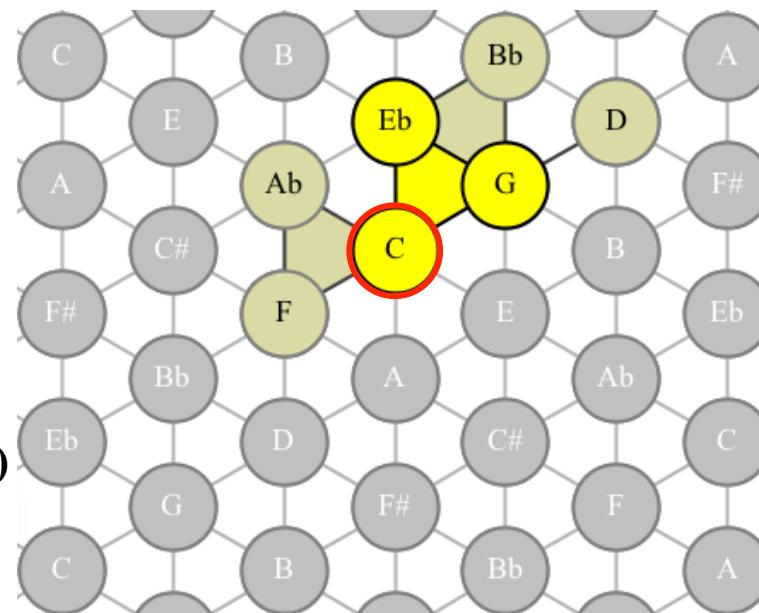
*Find all Hamiltonian Mathemusical Paths
that modulate through all minor triads
from f# min to b min, using only -1 or -3*



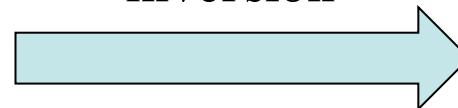
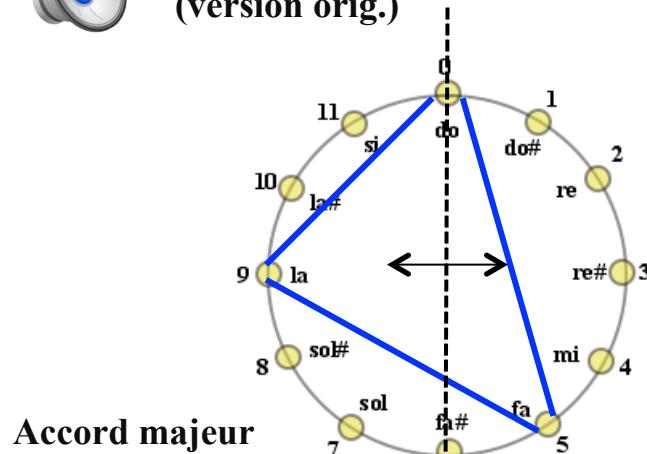
Maths et expériences oumu(po)piennes sur les Beatles



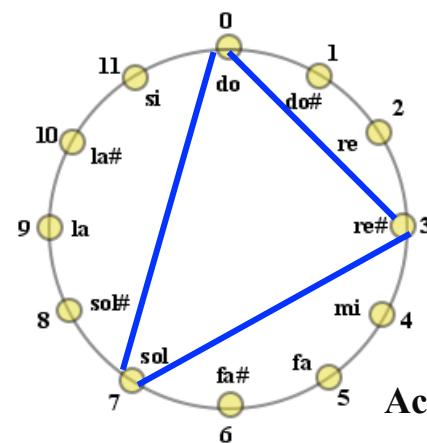
Rotation (autour du *do*)



Beatles, Hey Jude (version orig.)



Beatles, Hey Jude (version transformée)



→ <http://www.lacl.fr/~lbigo/scw13>