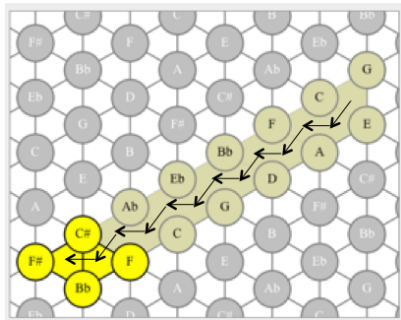
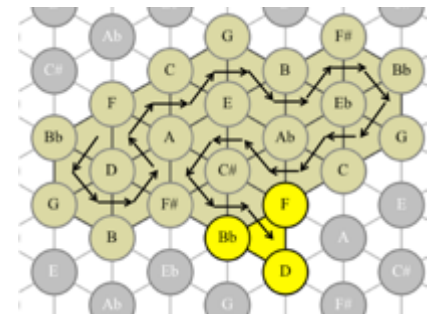


# *Hey Maths !*

## Modèles formels et computationnels au service des Beatles

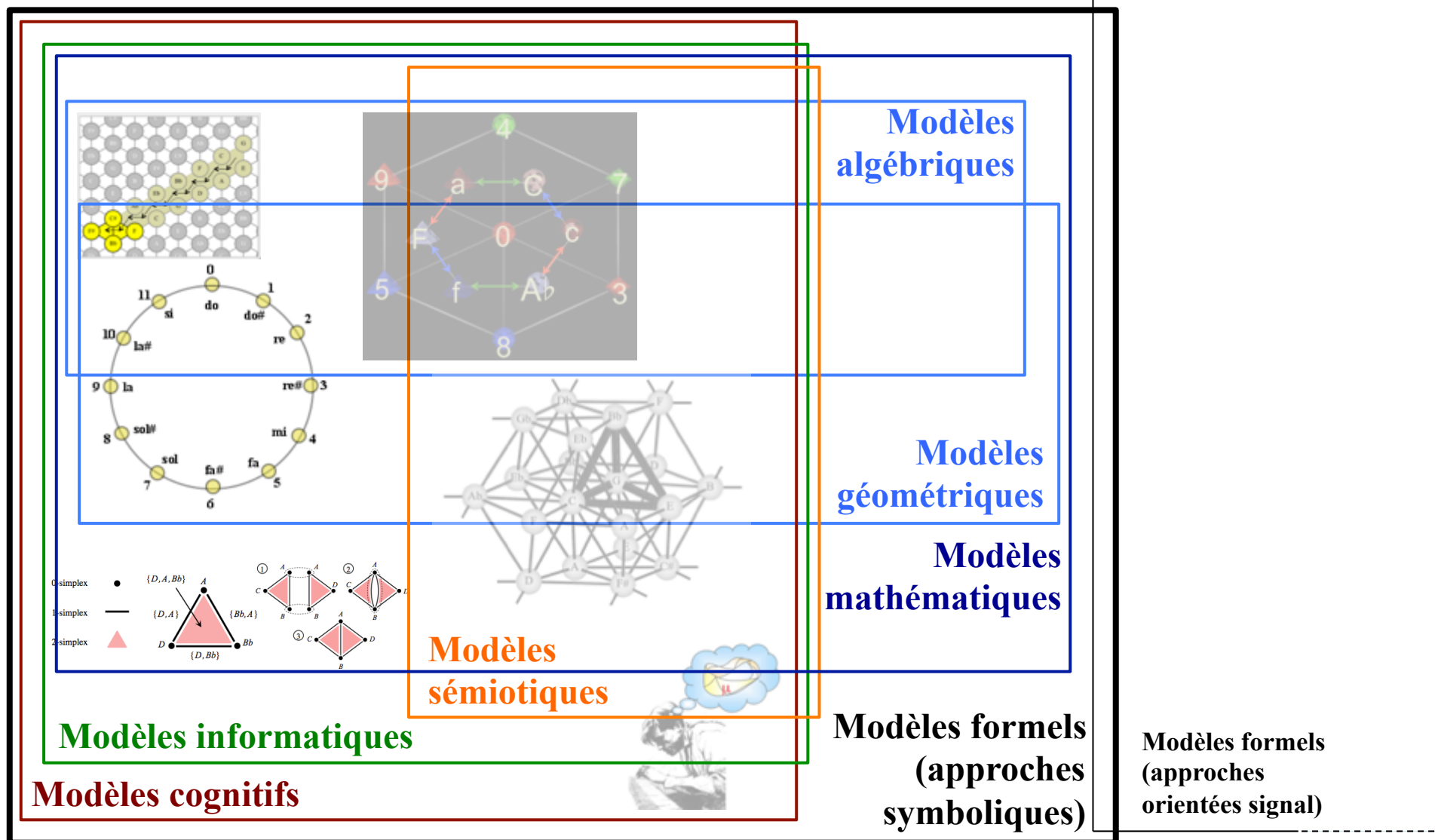


*Journée Beatles*  
*Evry*  
*6 novembre 2014*



Moreno Andreatta  
Equipe Représentations Musicales /  
IRCAM/CNRS UMR 9912

# Projet *Math'n Pop* : modèles formels *pour* et *dans* la musique pop



- Journée GDR ESARS sur les modèles formels et visualisations dans la pop (irDIVE, Lille, 15 avril 2014)
- Workshop “Math’n Pop” (ICMC-SMC Conference, Athènes, 14-20 septembre 2014)
- Colloque “Musique savante / musiques actuelles : articulations” (Ircam, 15-16 déc. 2014)



**Deadline :**  
**10 novembre**

# Articulations musique savante / *popular music* chez les Beatles

---

**Luciano Berio : Beatles Songs (1965-1967) arrangements pour voix et ensemble (1 voix soliste et ensemble jusqu'à 9 instruments).**

**Titres des parties :**

- *Michelle I*, pour mezzo-soprano et 2 flûtes ou flûte (ou hautbois) et clavecin, 2 minutes ;
- *Ticket to Ride*, pour mezzo-soprano et flûte, Hautbois, trompette clavecin, violon, alto, Violoncelle, contrebasse, 2 minutes ;
- *Yesterday*, pour mezzo-soprano et flûte, clavecin et violoncelle, 2 minutes ;
- *Michelle II*, pour mezzo-soprano et flûte, clarinette, harpe, violon, alto, violoncelle, contrebasse, 2 minutes.
- *Michelle II*, version transposée pour flûte, clarinette, harpe, violon, alto,



L. Berio (1925-2003)



C. Berberian (1925-1983)

➔ <http://www.youtube.com/watch?v=GvuxldwxW8k>

# Articulations musique savante / *popular music* chez les Beatles

Tōru Takemitsu (1974-1977), *Twelve Songs For Guitar*. Quatre songs des Beatles :

- Here, There and Everywhere
- Michelle
- Hey Jude
- Yesterday



Tōru Takemitsu (1930-1996)

イエスタデイ  
Yesterday

ジョン・レノン / ポール・マッカートニー  
武満 徹 編曲  
John Lennon and Paul McCartney  
arranged by Toru Takemitsu

Freely ♩ = 90~104

legato

mf

p

C VI C IV C II

③

p

mf

p

C II

mf

rall.

a tempo

C II

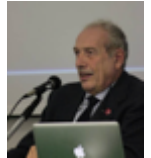
p

p



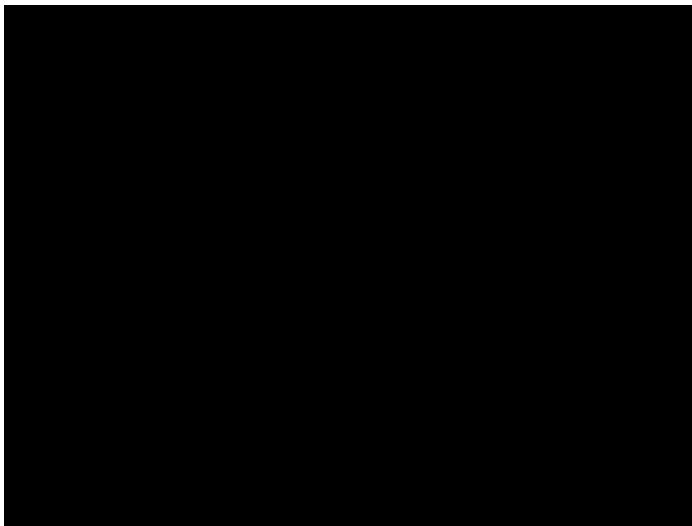
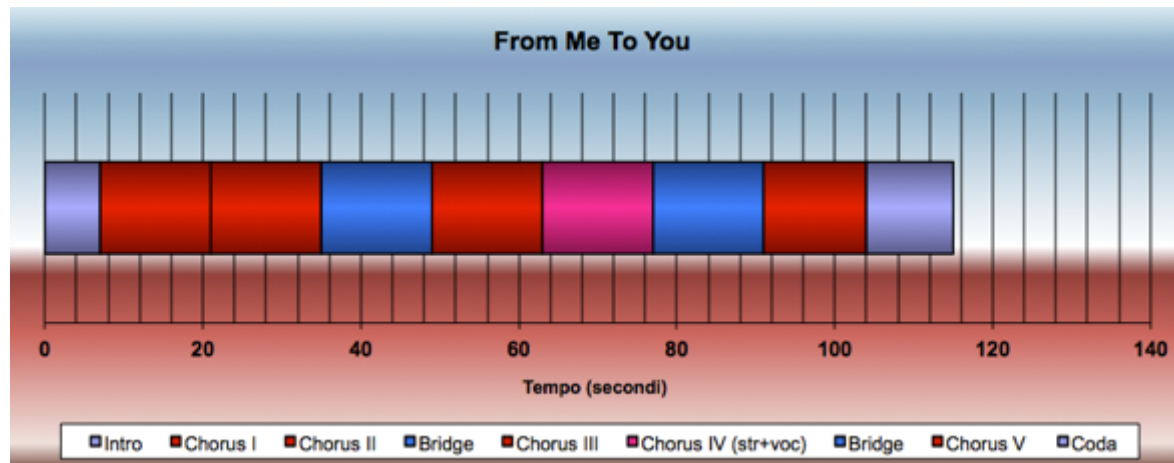
→ <http://www.youtube.com/watch?v=JnUZC3aFWmY>

# « Formes et modèles des chansons des Beatles »



F. Fabbri

- Franco Fabbri, « Forme e modelli delle canzoni dei Beatles », in Rossana Dalmonte (ed.), *Analisi e canzoni*. Univ. Trento, 1996, 169-196. (Repris dans *Il suono in cui viviamo. Inventare, produrre e diffondere musica*, Feltrinelli, 1996)
- Franco Fabbri, « Verse, Chorus (Refrain), Bridge: Analysing Formal Structures of the Beatles' Songs », *Popular Music Worlds, Popular Music Histories, Proceedings* (Geoff Stahl, Alex Gyde eds), 2012, IASPM: 92-109.



→ [www.youtube.com/watch?v=u8xhSeZi5CM](http://www.youtube.com/watch?v=u8xhSeZi5CM)

## Un peu de vocabulaire (Fabbri, 1996/2012)

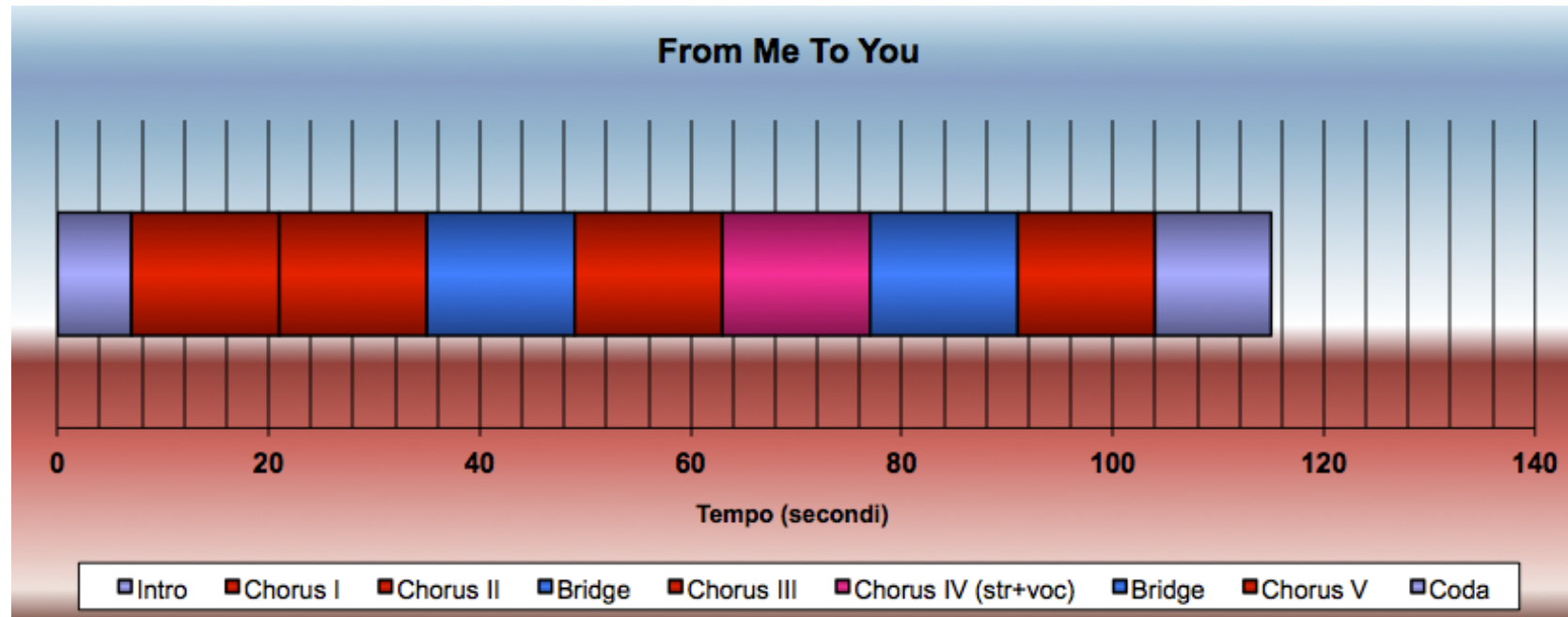
- **Refrain** : section d'une chanson dans laquelle la musique et les paroles sont toujours répétées de la même façon tout au long de la pièce et les paroles du texte contiennent le titre de la chanson
- **Chorus** : section d'une chanson dans laquelle la musique est répétée de la même façon tandis que les paroles varient. Certaines lignes du texte (dont le titre de la chanson) sont cependant répétées à l'identique
- **Verse** : section d'une chanson dans laquelle la musique est répétée de la même façon tandis que les paroles varient sans exception.
- **Bridge** : section d'une chanson qui se positionne après les chorus et dont elle diffère par caractère harmonique et mélodique

# « Formes et modèles des chansons des Beatles »

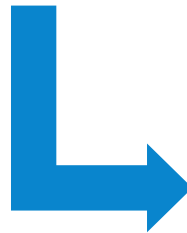


F. Fabbri

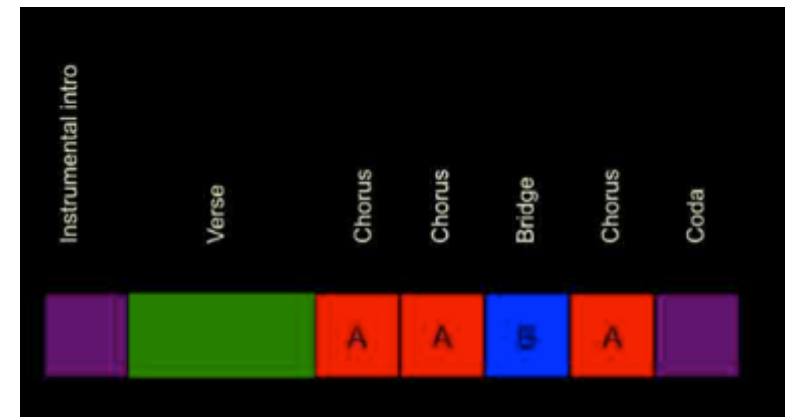
- Franco Fabbri, « Forme e modelli delle canzoni dei Beatles », in Rossana Dalmonte (ed.), *Analisi e canzoni*. Univ. Trento, 1996, 169-196. (Repris dans *Il suono in cui viviamo. Inventare, produrre e diffondere musica*, Feltrinelli, 1996)
- Franco Fabbri, « Verse, Chorus (Refrain), Bridge: Analysing Formal Structures of the Beatles' Songs », *Popular Music Worlds, Popular Music Histories, Proceedings* (Geoff Stahl, Alex Gyde eds), 2012, IASPM: 92-109.



*Love Me Do, Please Please Me, Ask Me Why, I Saw Her Standing There, Do You Want To Know A Secret, **From Me To You**, Thank You Girl, I'll Get You, I Want To Hold Your Hand, You Can't Do That, And I Love Her, I Should Have Known Better, A Hard Day's Night, I'll Cry Instead, I'll Be Back, Any Time At All, Things We Said Today, I Don't Want To Spoil The Party, No Reply, Eight Days A Week, I Feel Fine, I'll Follow The Sun, ...*



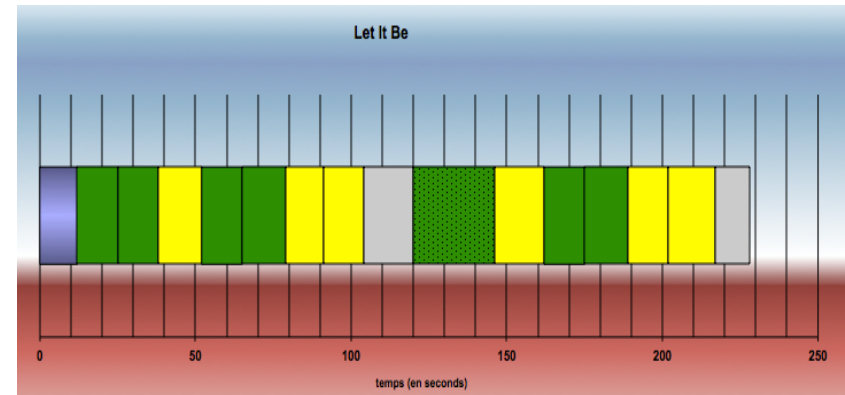
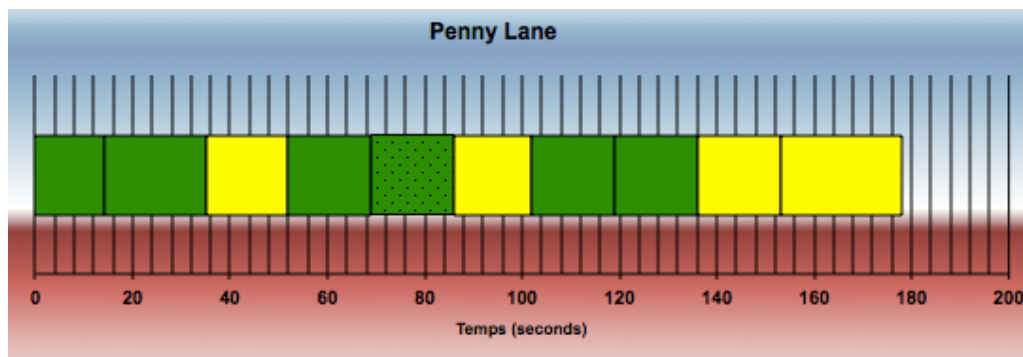
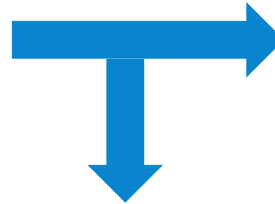
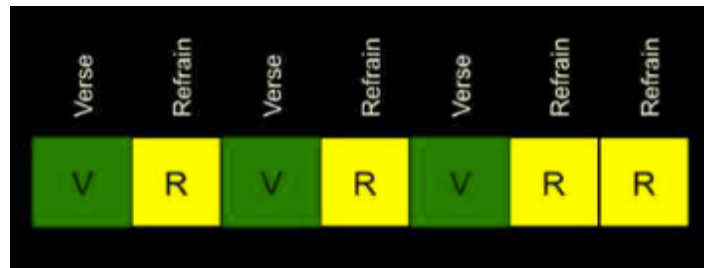
**Forme AABA  
(ou CB)**



# La forme Verse-Refrain ou Verse-Chorus (Covach)



J. Covach

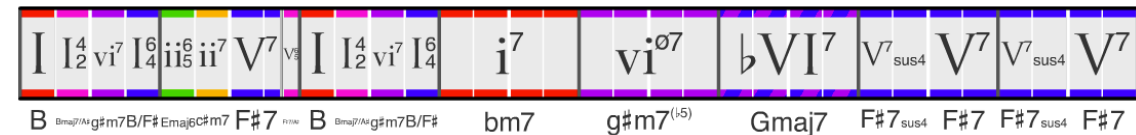


Fichier source : [www.francofabbri.net/](http://www.francofabbri.net/)

0:00-0:14  
0:18-0:35  
0:35-0:52

**Verse 1, 8 mm., 8a**  
**Verse 2, 8 mm., 8b**  
**Chorus, 8 mm.**

**a**



0:52-1:09  
1:09-1:26  
1:26-1:42

**Verse 3, 8 mm., 8a**  
**Verse (instrumental), 8 mm., 8b**  
**Chorus, 8 mm.**

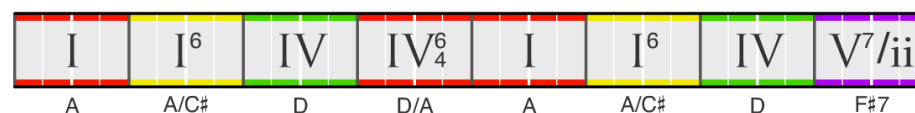
**b**



1:42-1:59  
1:59-2:16  
2:16-2:33  
2:33-2:58

**Verse 4, 8 mm., 8a**  
**Verse 5, 8 mm., 8b**  
**Chorus, 8 mm.**  
**Chorus, 9 mm., 8 mm. in B, with 1 m. added at end**

**Chorus**



<http://www.hooktheory.com/analysis/>

- J. Covach, « Form in Rock Music: A Primer », in *Engaging Music: Essays in Music Analysis*, ed. Deborah Stein (New York and Oxford: Oxford University Press, 2005).
- J. Covach, « From 'Craft' to 'Art': Formal Structure in the Music of the Beatles », In *Reading the Beatles: Cultural Studies, Literary Criticism, and the Fab Four*, ed. Kenneth Womack and Todd F. Davis, 37–54. State University of New York Press.

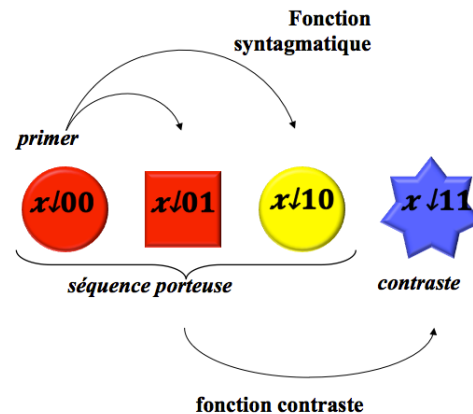
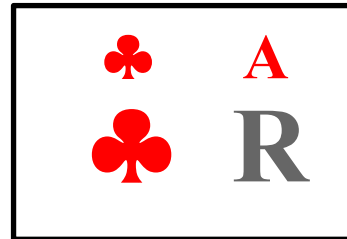
# Le modèle « système-contraste » pour l'analyse musicale

Le modèle S/C : modèle polymorphe qui décrit l'organisation interne des segments



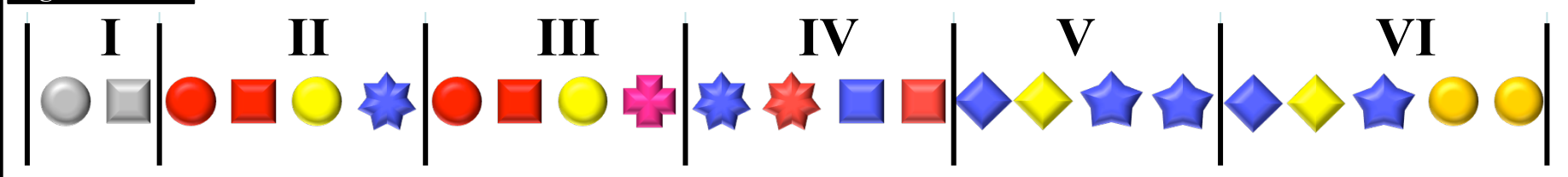
F. Bimbot

## Exemples de S&C



- F. Bimbot, E. Deruty, G. Sargent et E. Vincent, “Semiotic Structure Labeling of Music Pieces: Concepts, Methods and Annotation Conventions”, ISMIR, 2012.
- F. Bimbot, “Concepts and methods for the description and the annotation of the semiotic structure of music pieces”, Journée “Modèles formels dans la pop”, Lille, GDR ESARS, 2013.
- F. Bimbot, E. Deruty, “The “system-contrast” model for the segmentation and structural annotation of popular music pieces starting from audio signal”, Workshop “Math’n Pop”, ICMC-SMC, Athènes, septembre 2014.

## Segmentation



Base de données annotées → <http://musicdata.gforge.inria.fr>

# Modèle S&C et structures sémiotiques en analyse musicale

**Structure sémiotique** : retranscription de la structure haut-niveau d'une pièce de musique en tant que séquence de symboles d'un alphabet fini

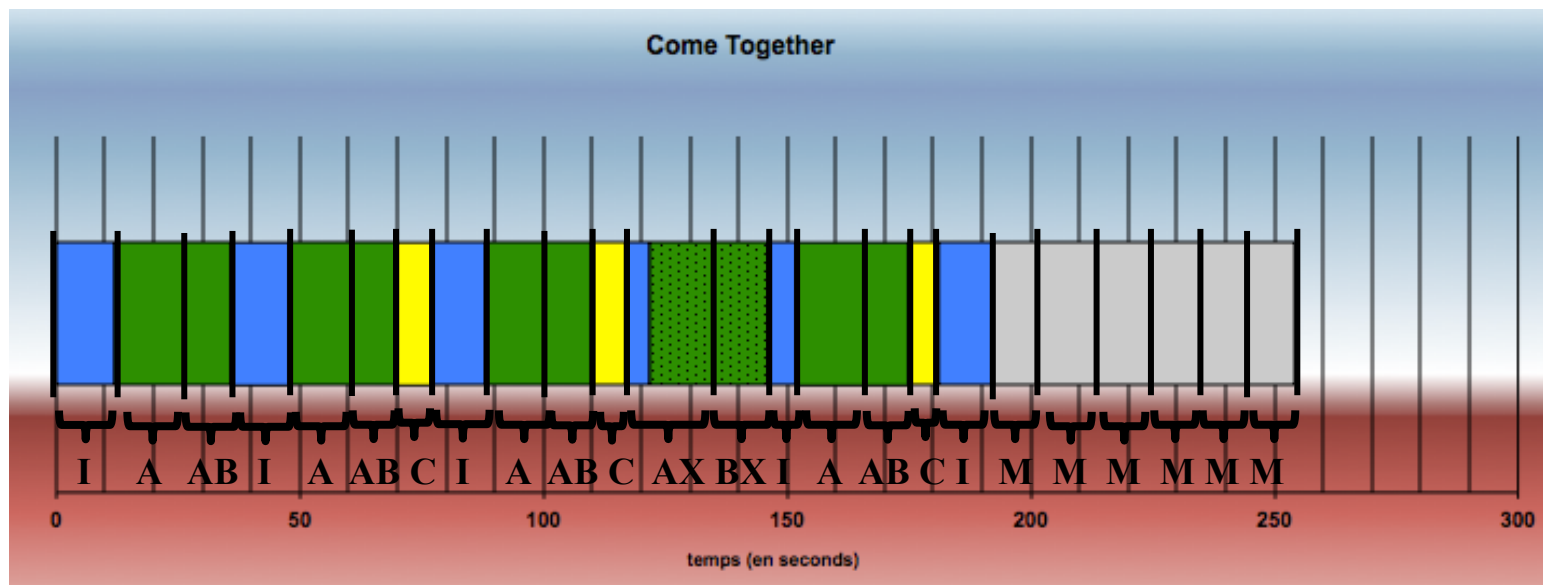
- Une *unité* = 1 segment structurel
- Un *symbole* = 1 classe d'équivalence



Ph. Tagg

Les trois composantes de la *structure sémiotique* :

- *Analyse morphologique* (consistance interne des segments --> modèle S&C)
- *Analyse syntagmatique* (relations entrée les segments et leurs voisinages)
- *Analyse paradigmatic* (classes d'équivalence induites par une relation de similarité entre les segments)



# Modèle S&C et alignements multiples de séquences



Ph. Esling



M. Bergomi

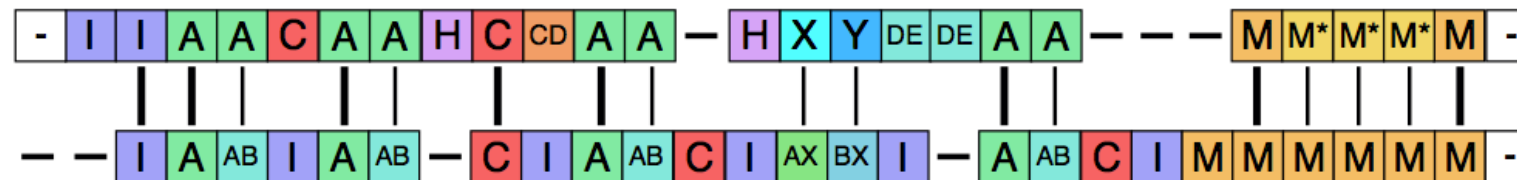
- Ph. Esling, M. Bergomi, « Rock Around the Molecular Clock » (paper in preparation, preliminary results of the « Math'n Pop » Workshop, ICM-SMC Conference, Athens, 14-20 septembre 2014)

The Beatles - *Come together*    I A AB I A AB C I A AB C AX BX I A AB C I M M M M M M M -

The Cure - *The figurehead*    - I I A A C A A H C CD A A H X Y DE DE A A M M\* M\* M\* M -



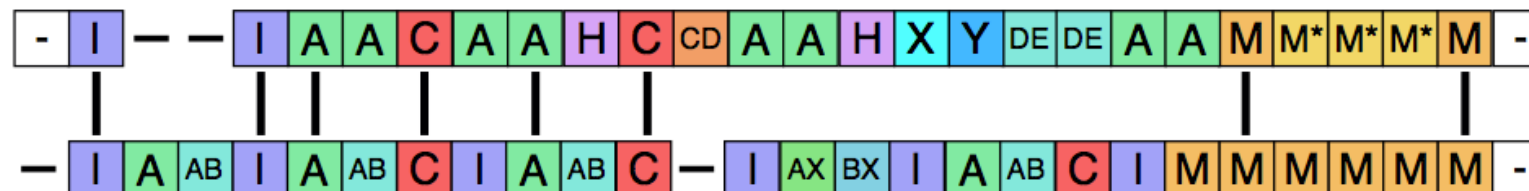
The Cure - *The figurehead*



The Beatles - *Come together*



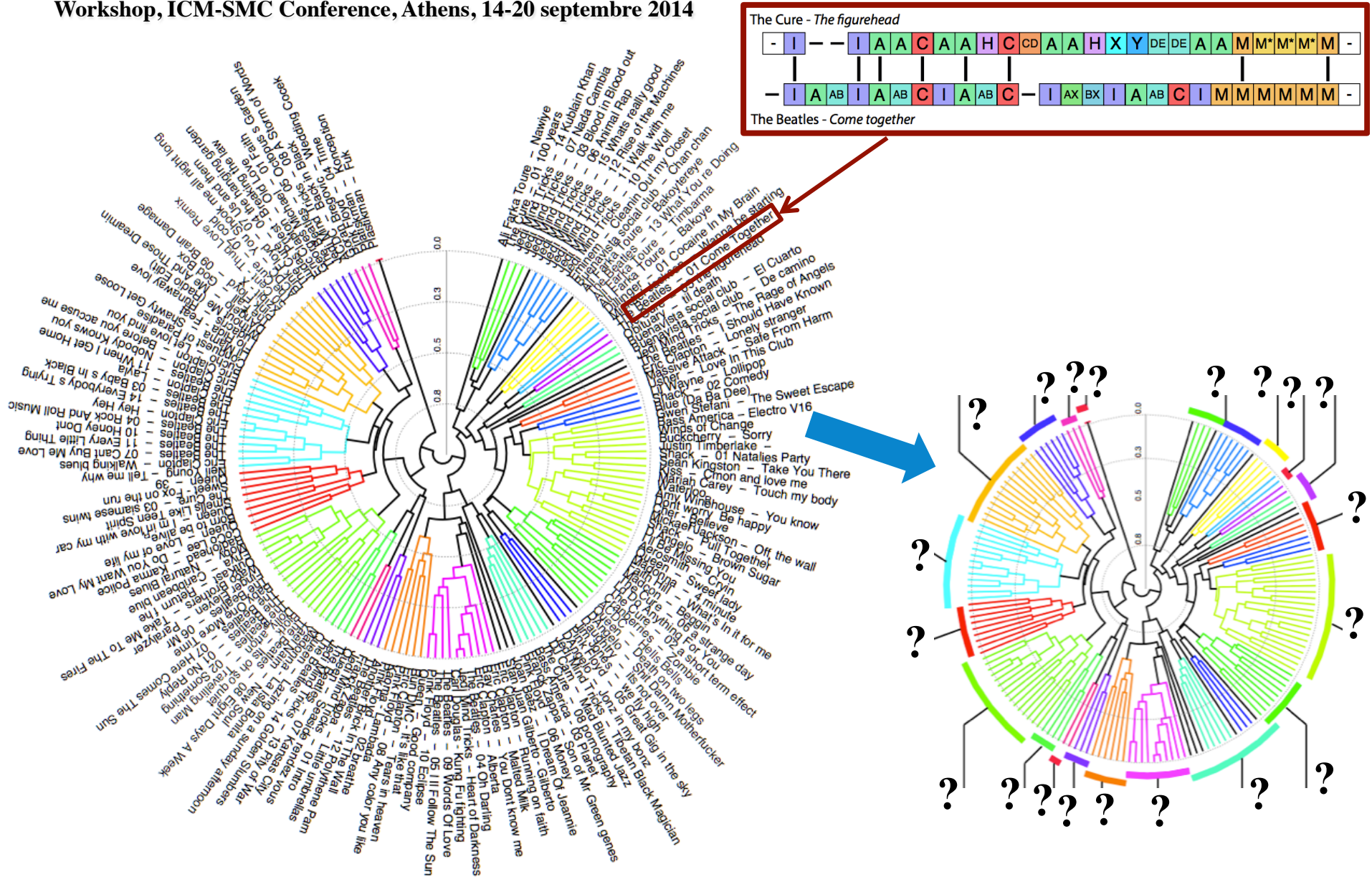
The Cure - *The figurehead*



The Beatles - *Come together*

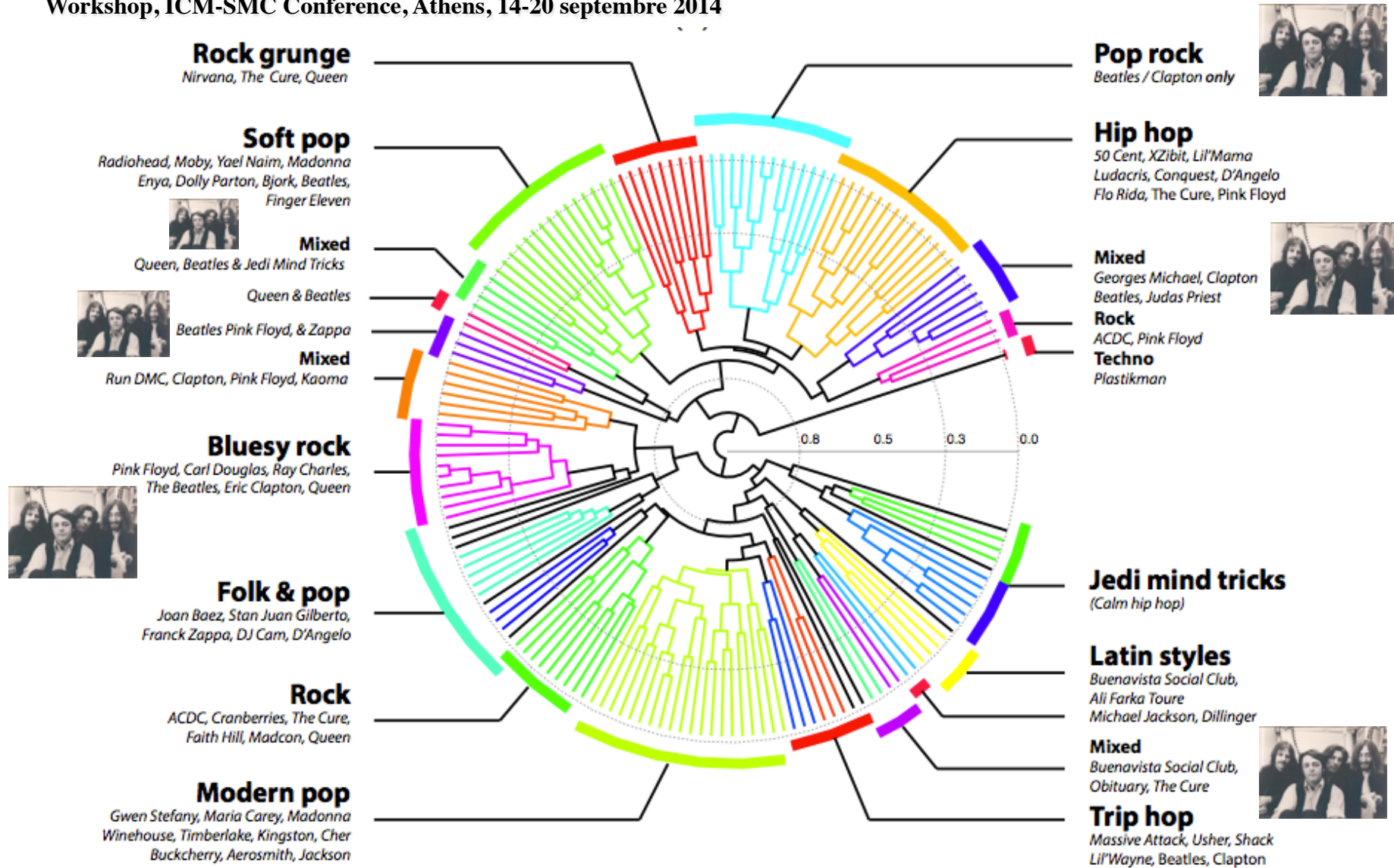
# L'horloge moléculaire de la pop (database *Quaero* : ~159 morceaux)

- Ph. Esling, M. Bergomi, « Rock Around the Molecular Clock » (paper in preparation, preliminary results of the « Math'n Pop » Workshop, ICM-SMC Conference, Athens, 14-20 septembre 2014)



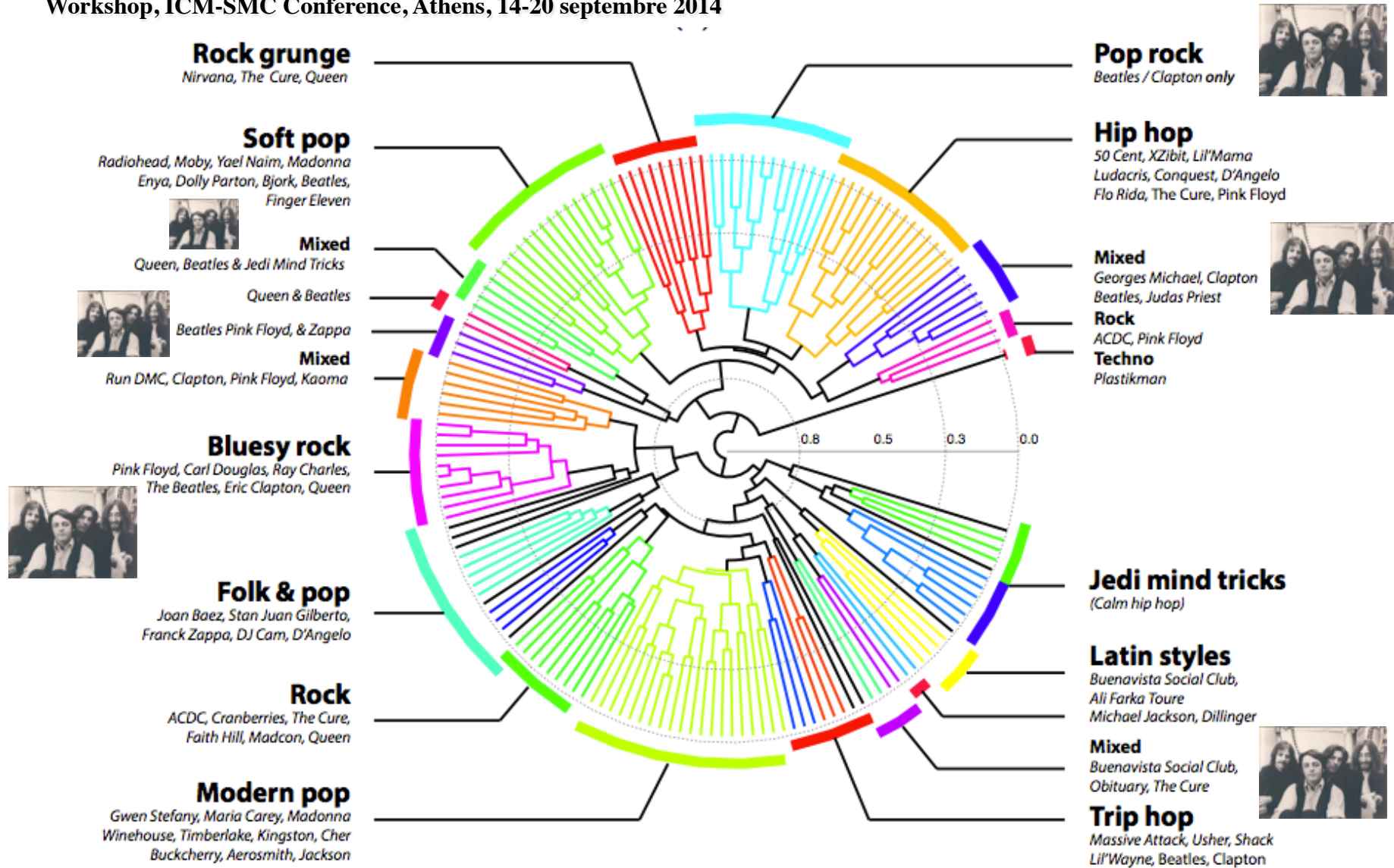
# Les chansons des Beatles dans l'horloge moléculaire

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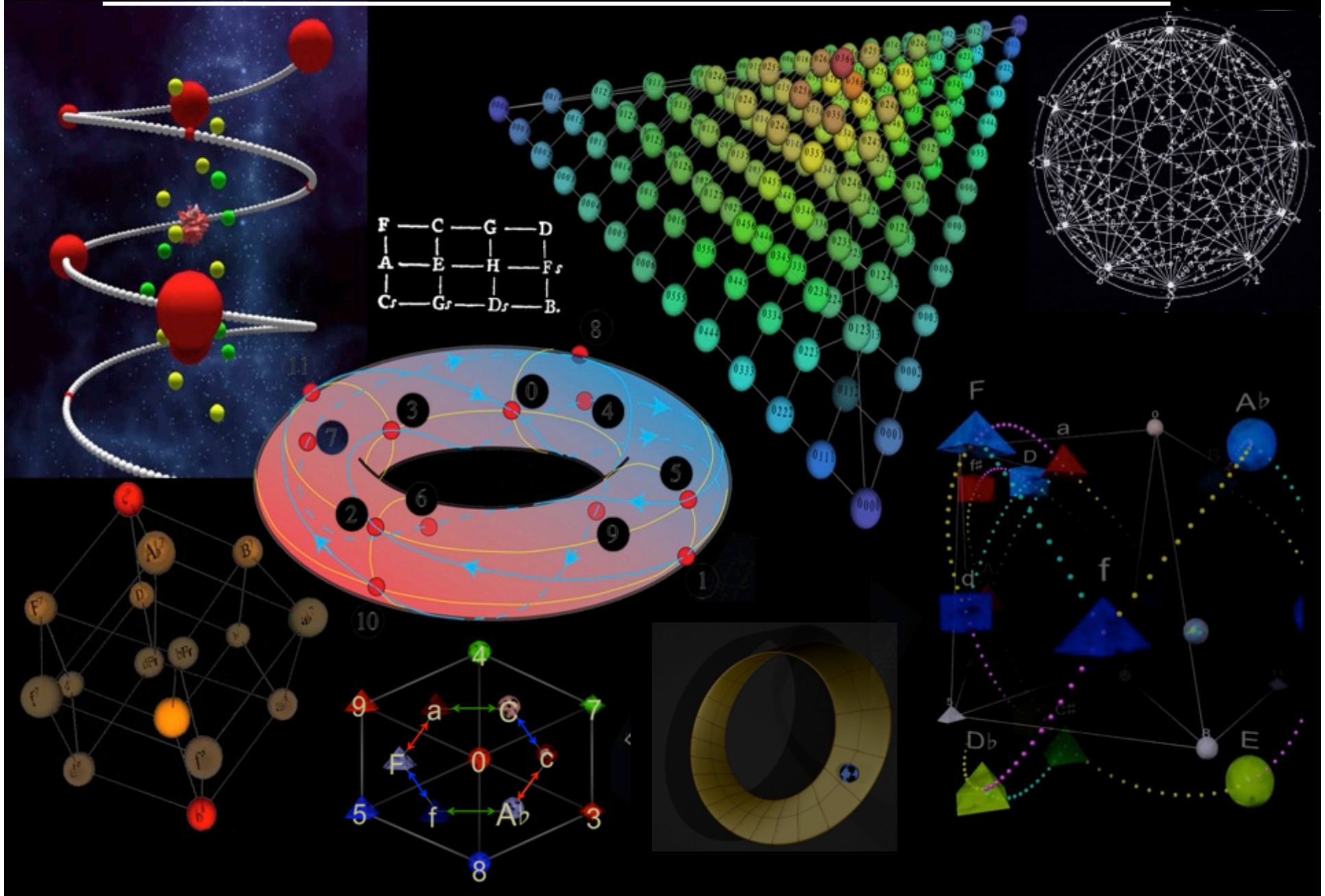
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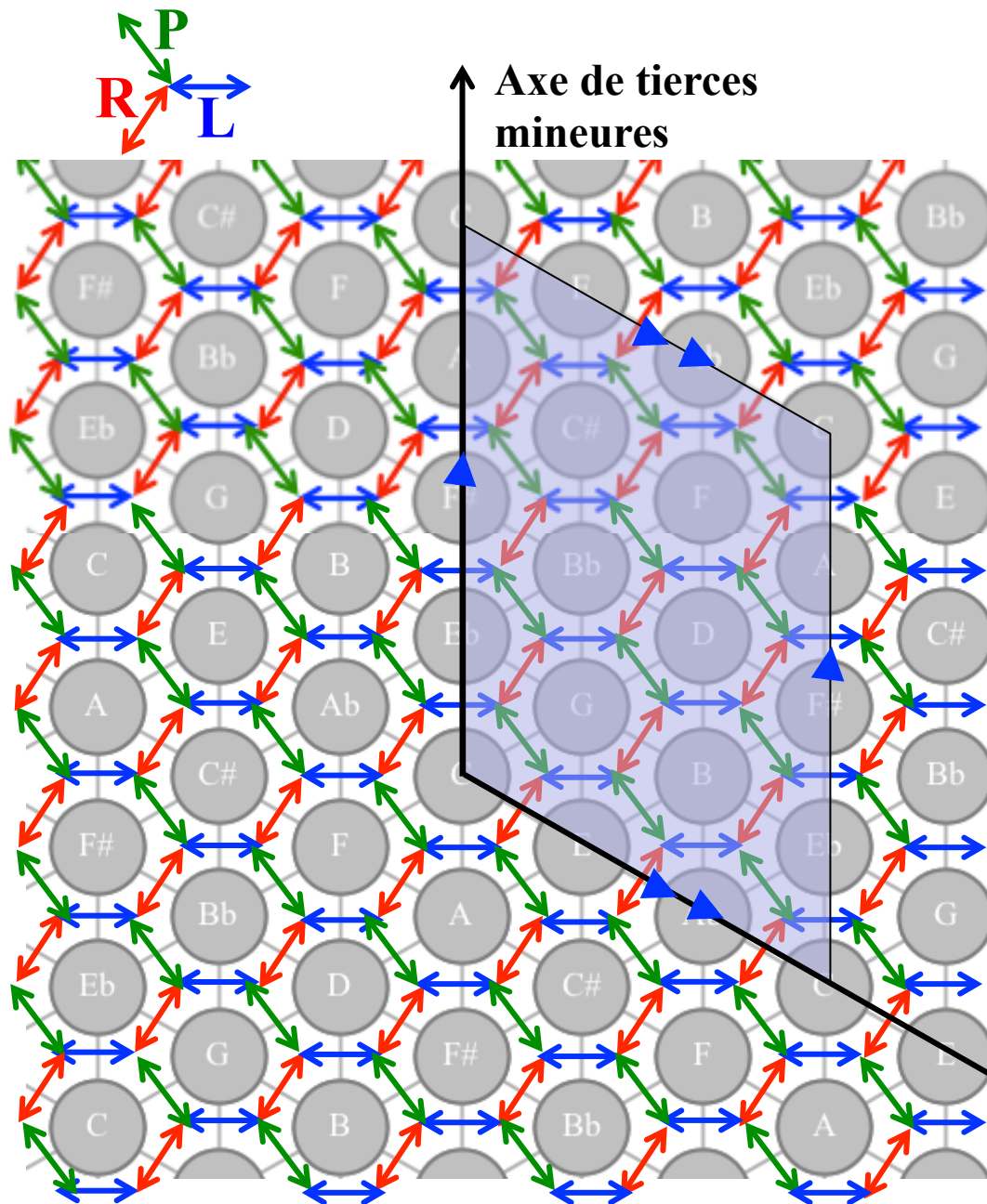


➔ Comment récupérer l'information harmonique ?

# La galaxie des modèles géométriques au service de la musique



# Du miroir de la musique au *Tonnetz*



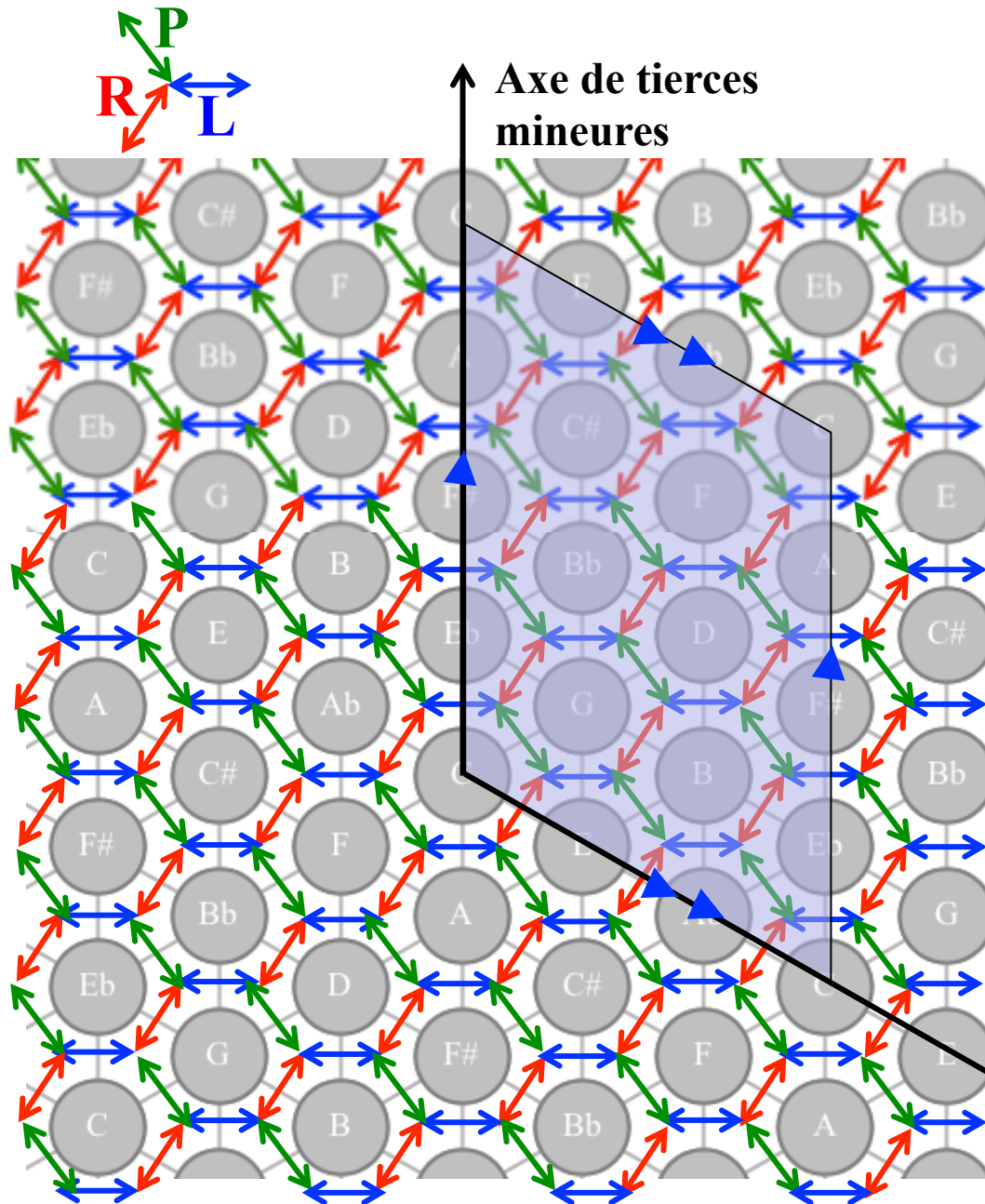
|                      |   |                      |   |                      |   |                      |
|----------------------|---|----------------------|---|----------------------|---|----------------------|
| <b>F</b>             | — | <b>C</b>             | — | <b>G</b>             | — | <b>D</b>             |
| <b>A</b>             | — | <b>E</b>             | — | <b>H</b>             | — | <b>F<sub>s</sub></b> |
| <b>C<sub>s</sub></b> | — | <b>G<sub>s</sub></b> | — | <b>D<sub>s</sub></b> | — | <b>B</b>             |



*Speculum Musicum* (Euler, 1773)



# Du miroir de la musique au *Tonnetz*



|                      |   |                      |   |                      |   |                      |
|----------------------|---|----------------------|---|----------------------|---|----------------------|
| <b>F</b>             | — | <b>C</b>             | — | <b>G</b>             | — | <b>D</b>             |
| <b>A</b>             | — | <b>E</b>             | — | <b>H</b>             | — | <b>F<sub>s</sub></b> |
| <b>C<sub>s</sub></b> | — | <b>G<sub>s</sub></b> | — | <b>D<sub>s</sub></b> | — | <b>B</b>             |

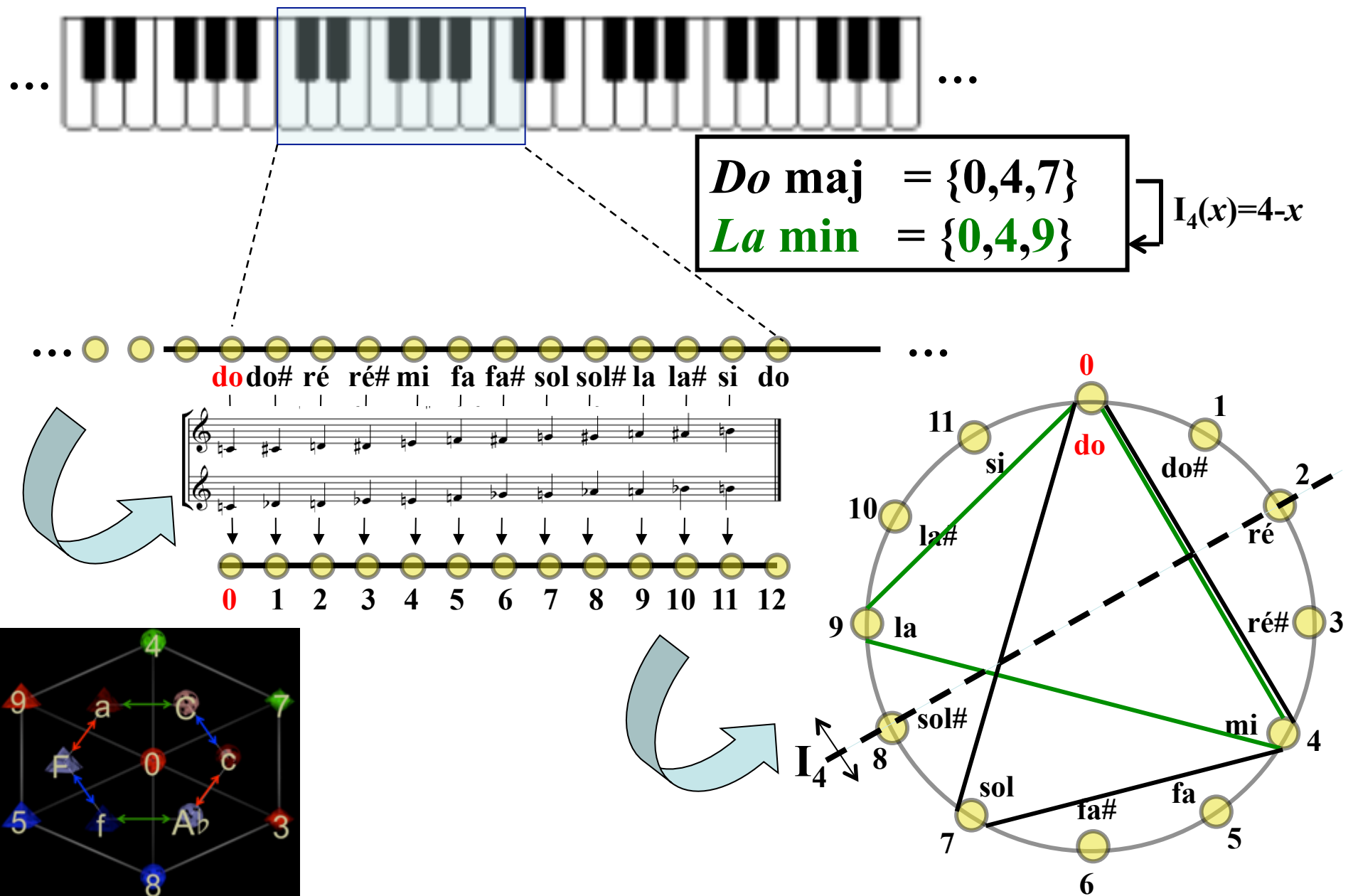


*Speculum Musicum* (Euler, 1773)

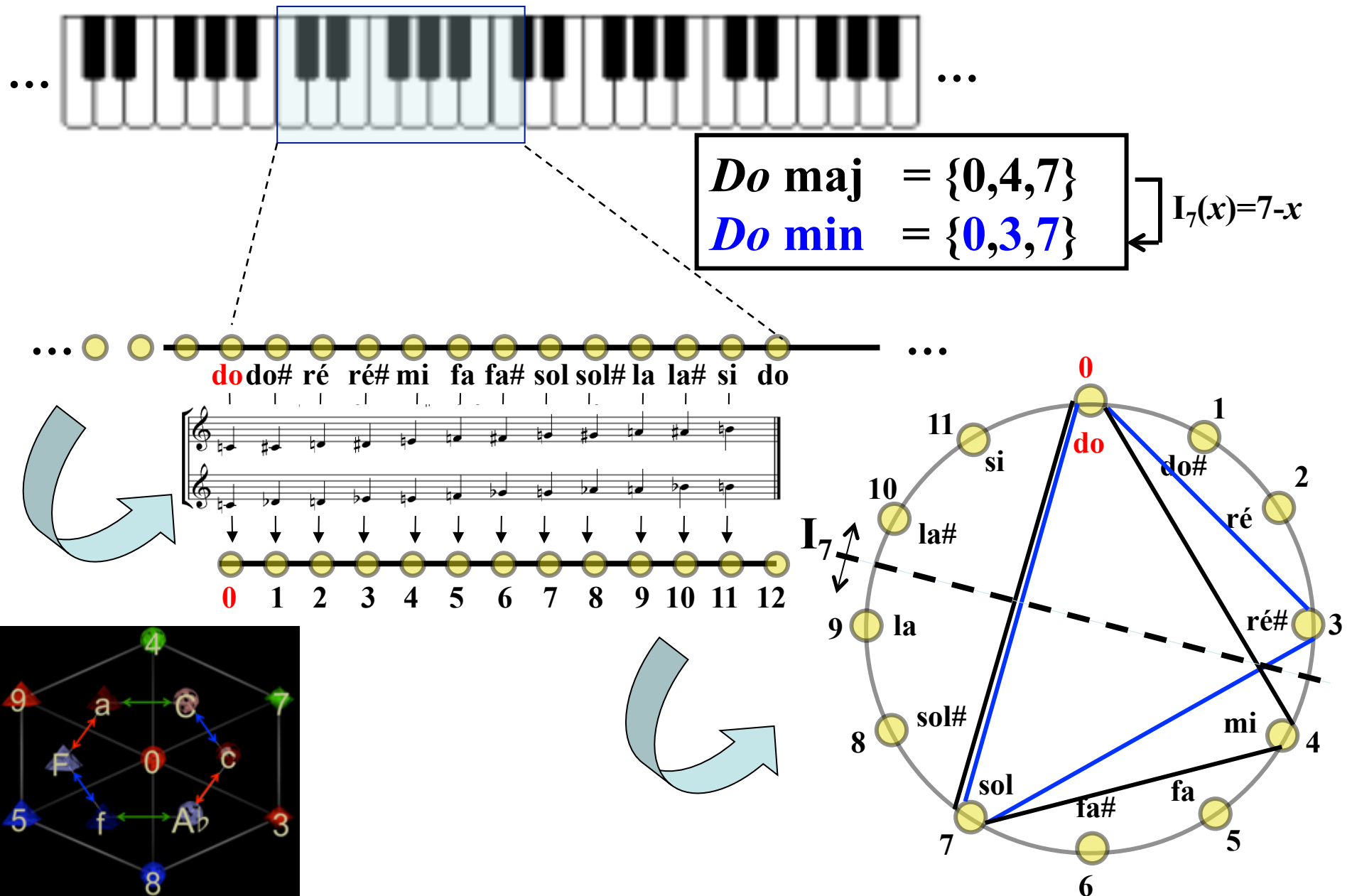


**Tore**

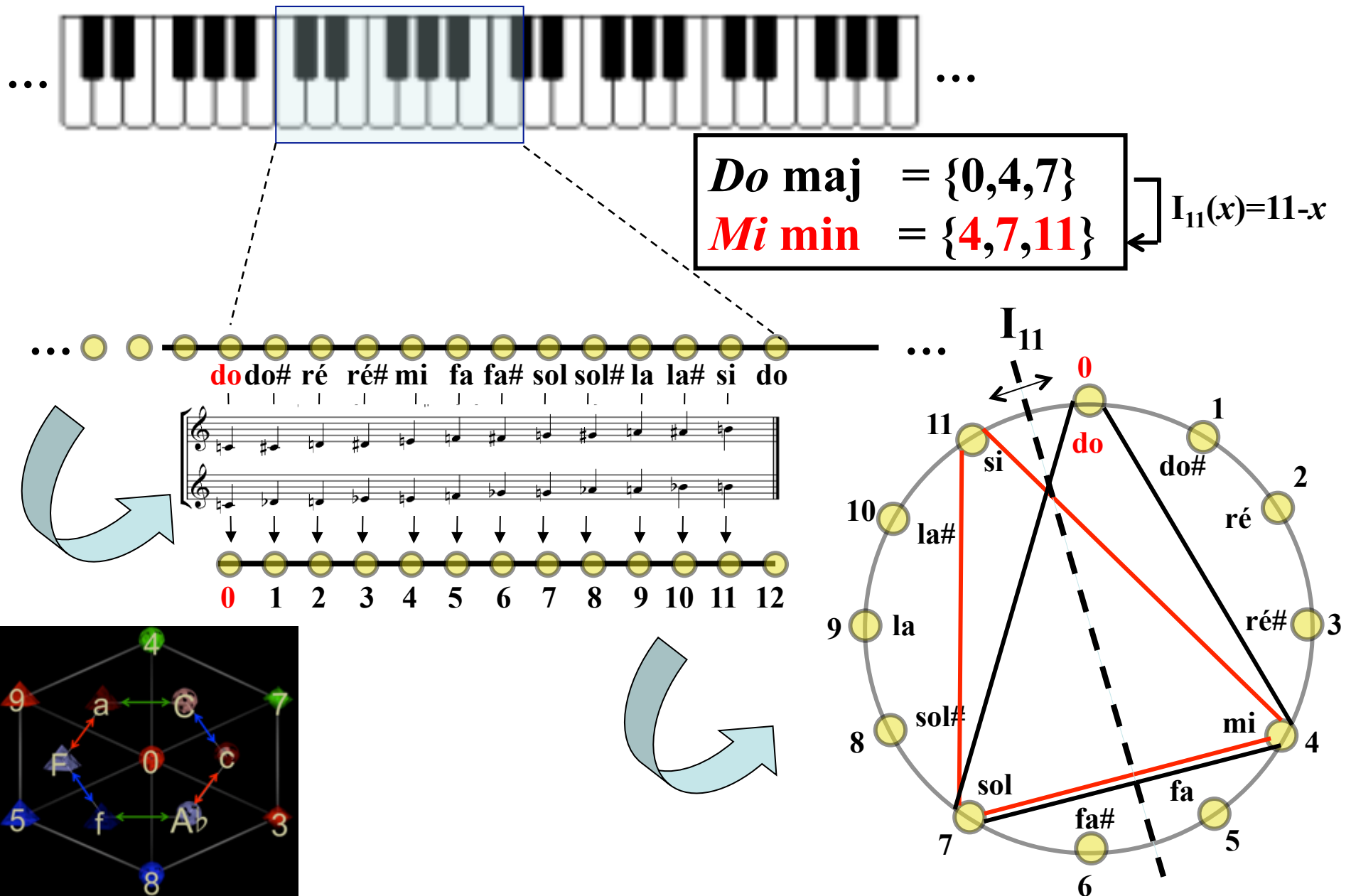
# Les trois opérateurs néo-riemanniens : **R**



# Les trois opérateurs néo-riemanniens : **P**



# Les trois opérateurs néo-riemanniens : **L**





# Progressions harmoniques chez Zappa

Synthesizer

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

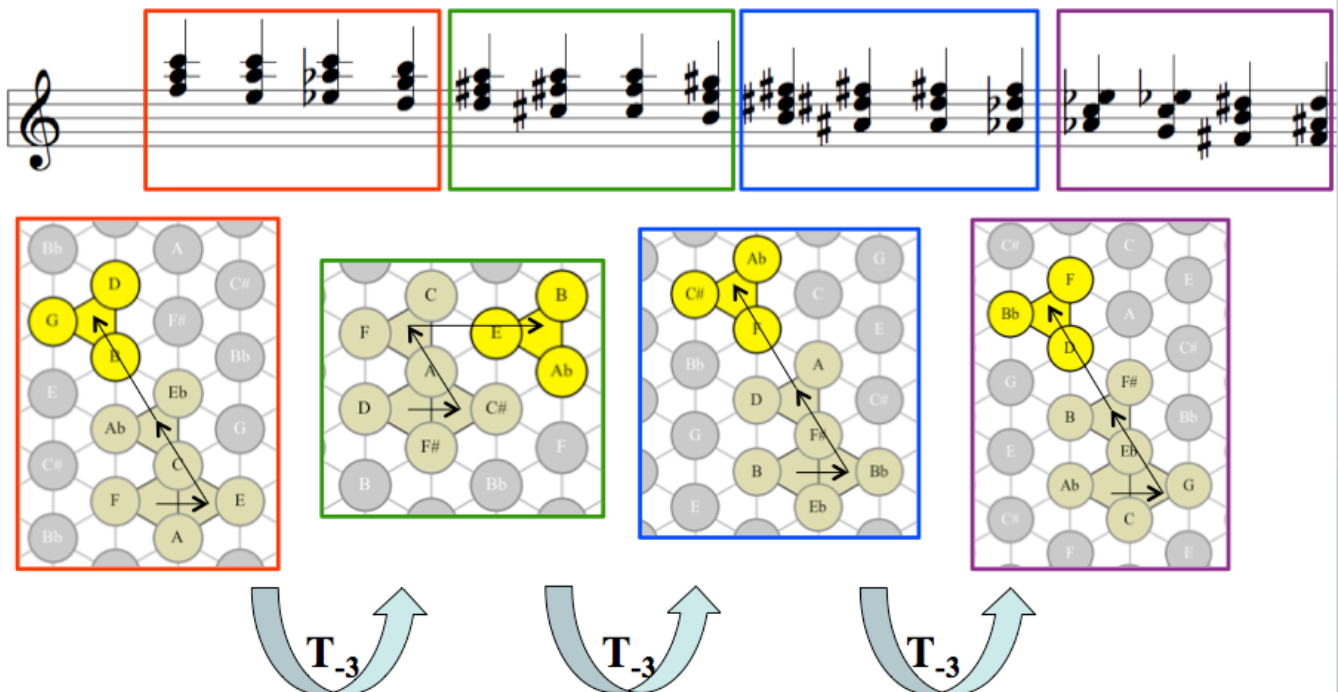
Figures:  $\frac{5}{3}$ ,  $\frac{6}{4}$ ,  $\frac{5}{3}$ ,  $\frac{5}{3}$ ,  $\frac{6}{4}$ ,  $\frac{5}{3}$

*Fine* *D.C. al Fine*

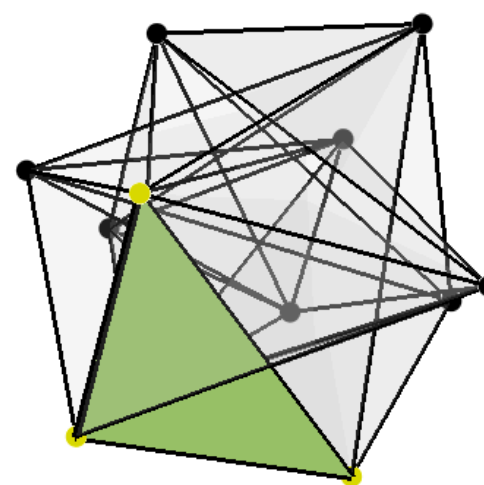
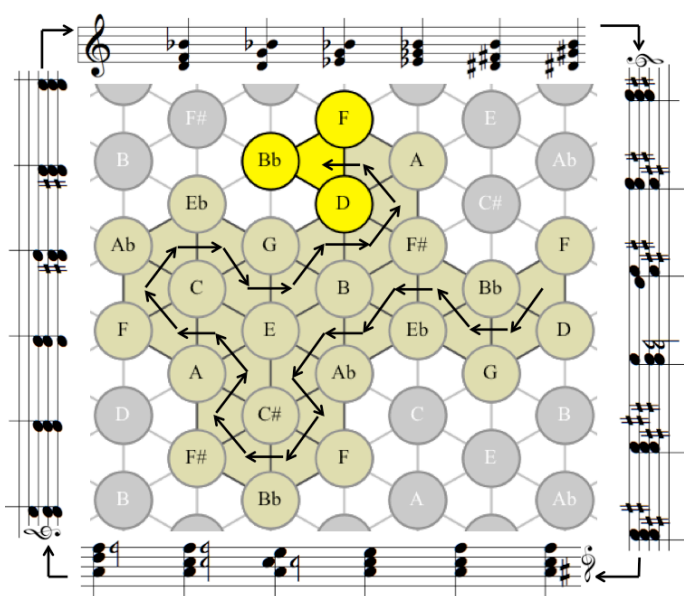
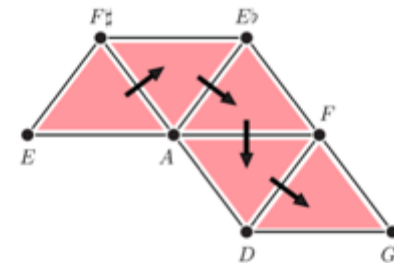
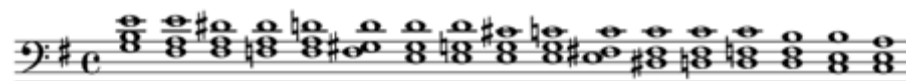
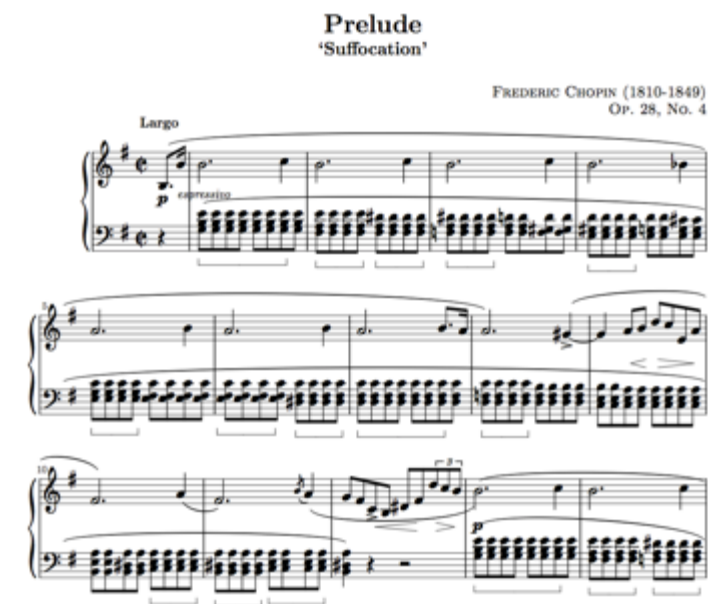
Guy Capuzzo, Neo-Riemannian Theory and the Analysis of Pop-Rock Music, *MTS*, 26/2, 2004, 177–200



« Easy Meat » - 1981 (F. Zappa)  
min. 1'44" – 2'39"



# Structures topologiques associées à une progression



**ACTIONS**

**Math'n'pop**

**→ Hexachord**

**Aprile (d'après Gabriele D'Annunzio)**



# L'espace géométrique comme paramètre de style

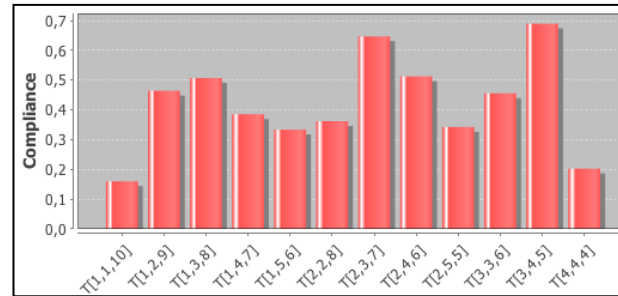
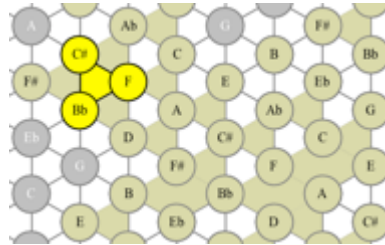
Louis Bigo, *Représentation symboliques musicales et calcul spatial*, PhD, Ircam / LACL, 2013



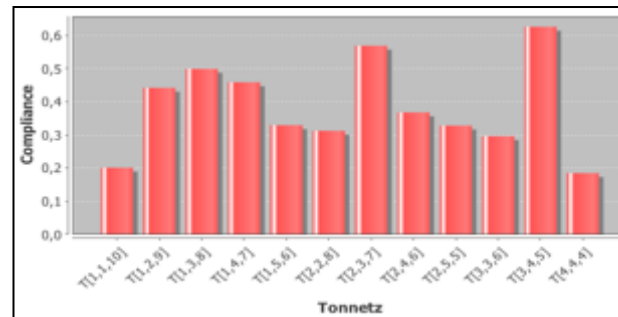
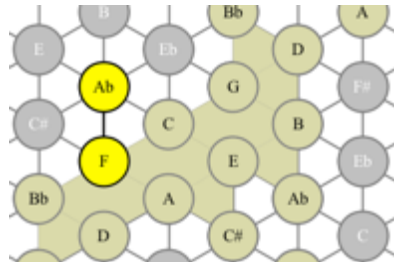
L. Bigo



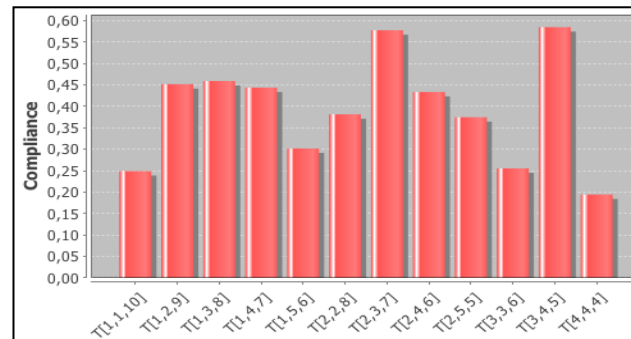
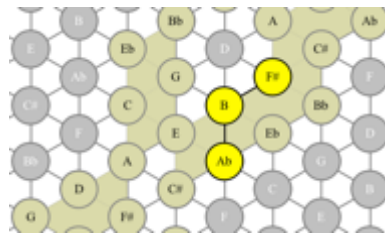
Thelonious Monk,  
Brilliant Corners



Chick Corea,  
Eternal Child



Bill Evans,  
Turn Out the Stars



# L'espace géométrique comme paramètre de style

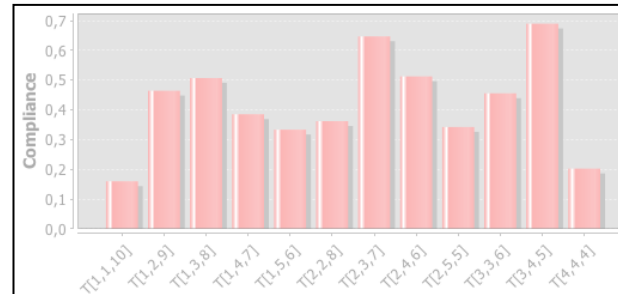
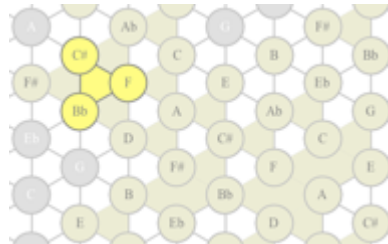
Louis Bigo, *Représentation symboliques musicales et calcul spatial*, PhD, Ircam / LACL, 2013



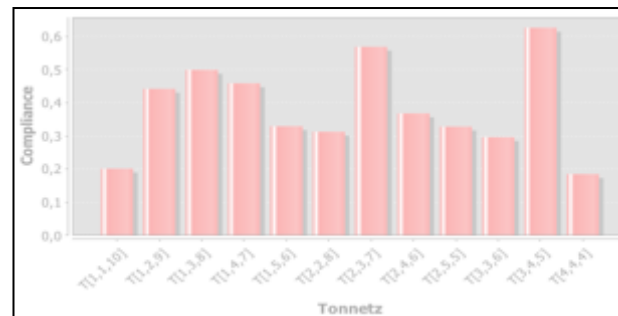
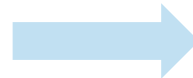
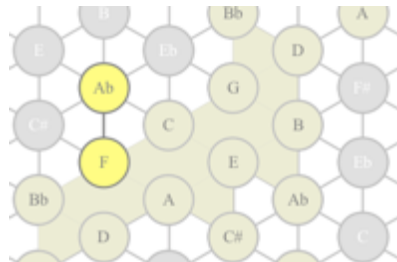
L. Bigo



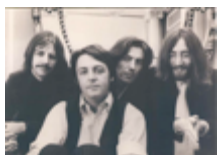
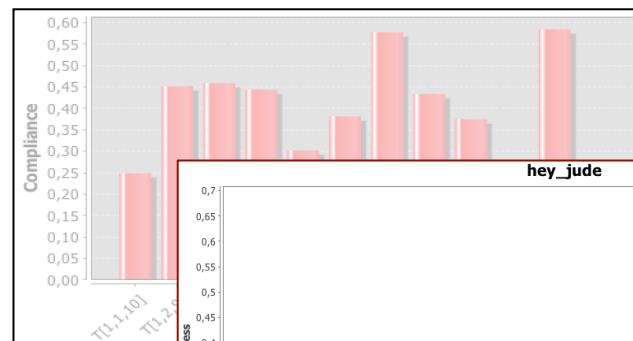
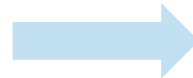
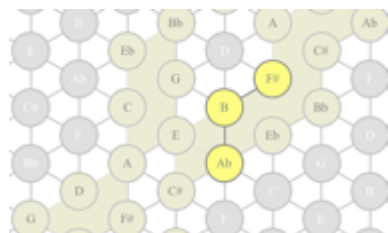
Thelonious Monk,  
Brilliant Corners



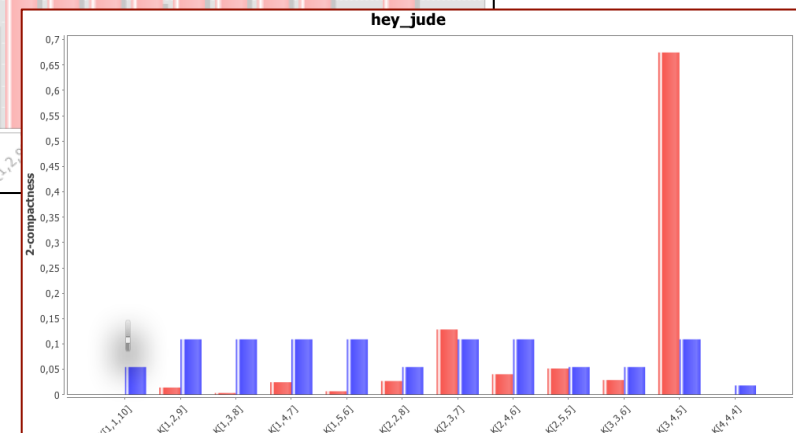
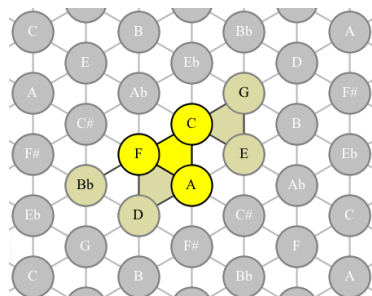
Chick Corea,  
Eternal Child



Bill Evans,  
Turn Out the Stars



The Beatles,  
Hey Jude



# L'espace géométrique comme paramètre de style

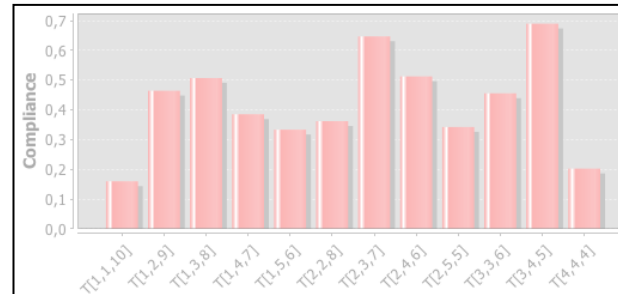
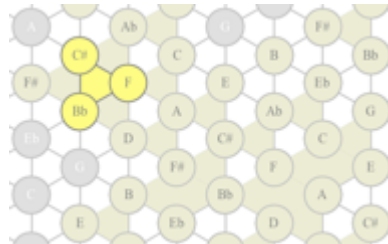
Louis Bigo, *Représentation symboliques musicales et calcul spatial*, PhD, Ircam / LACL, 2013



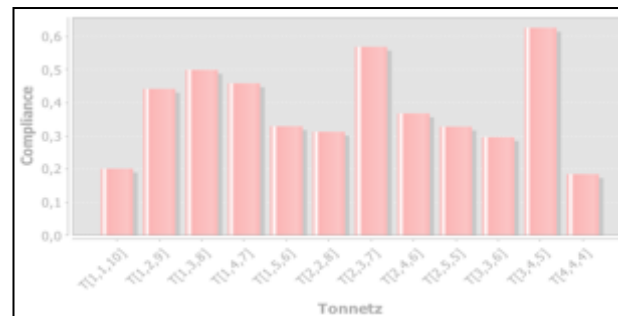
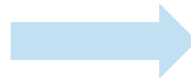
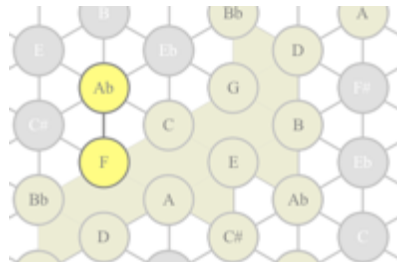
L. Bigo



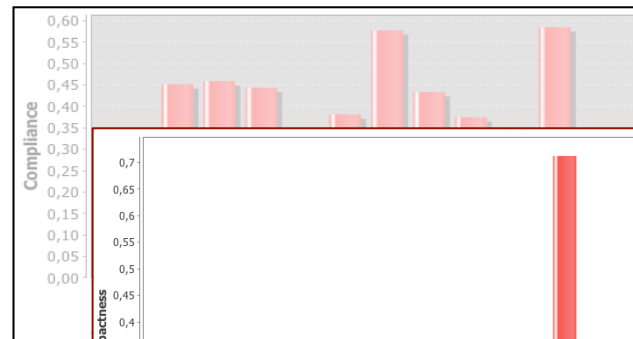
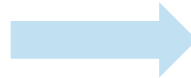
Thelonious Monk,  
Brilliant Corners



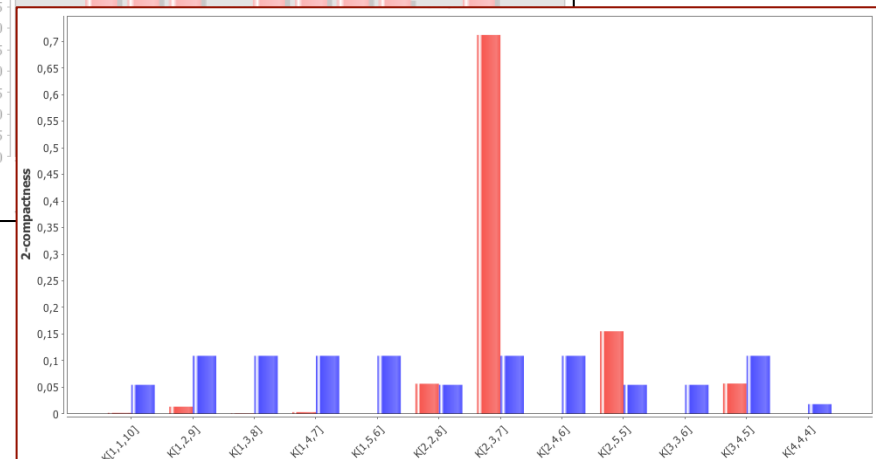
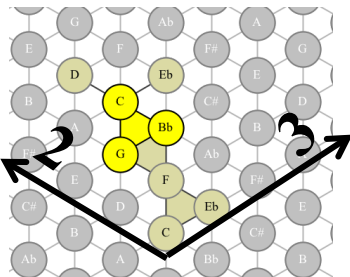
Chick Corea,  
Eternal Child



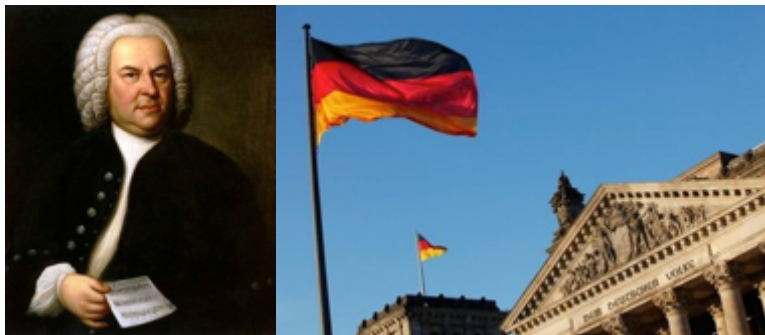
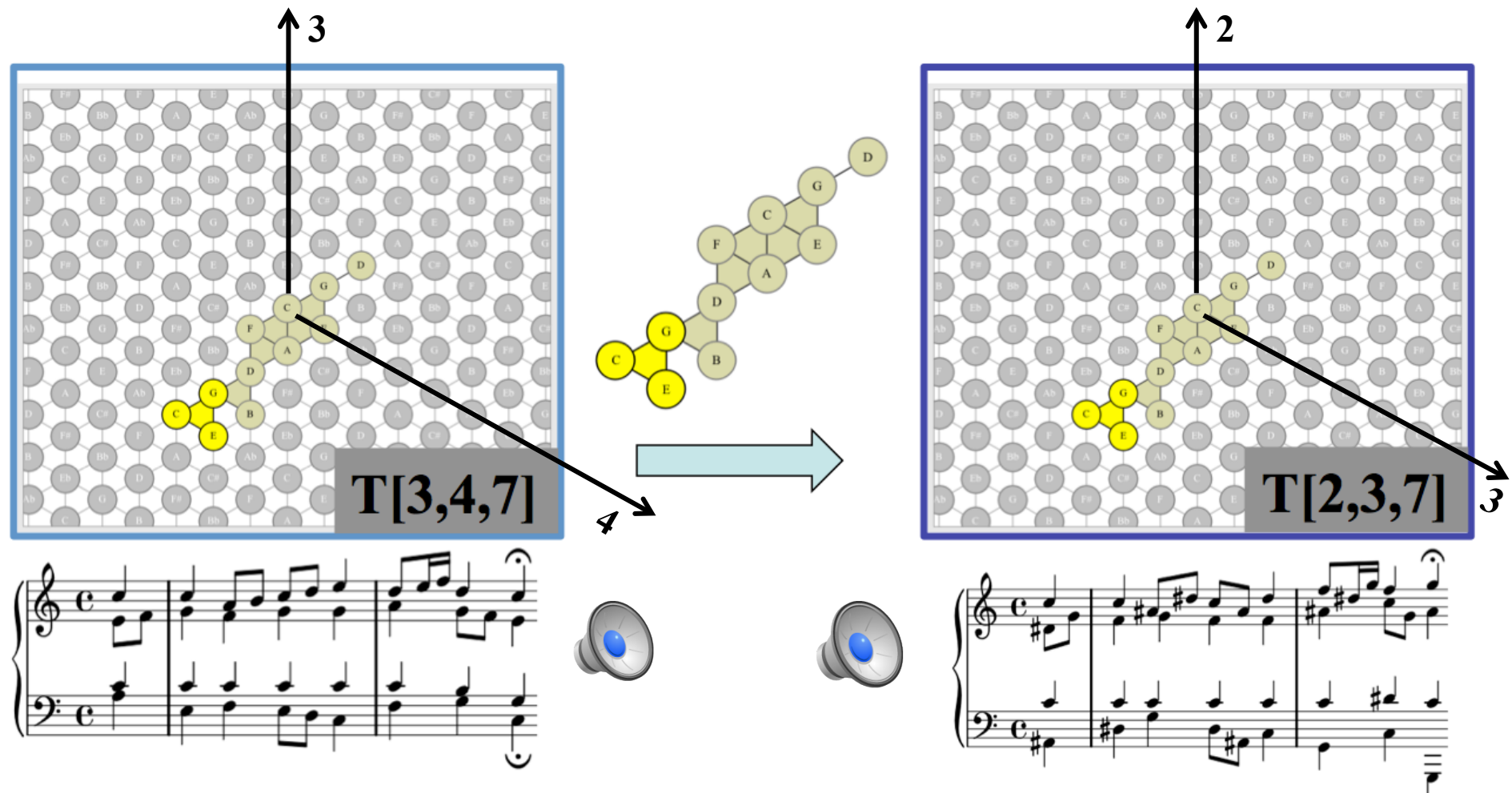
Bill Evans,  
Turn Out the Stars



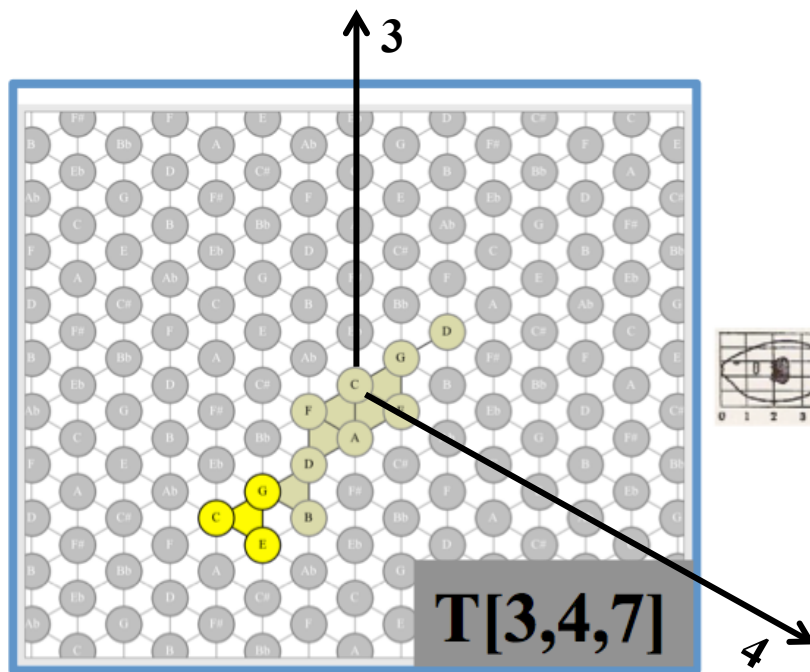
'The Beatles',  
Hey Jude



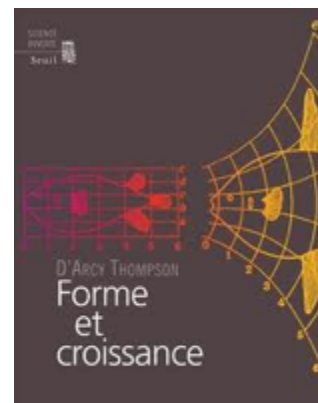
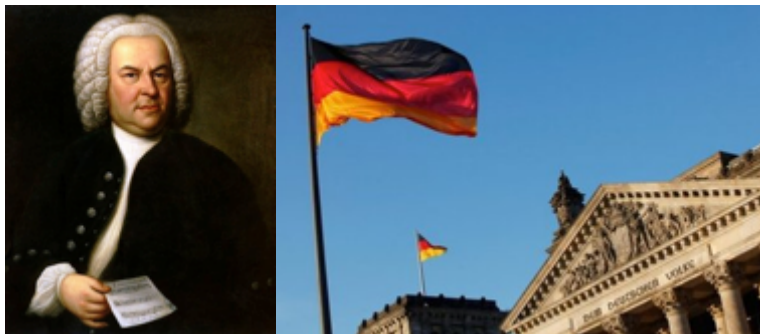
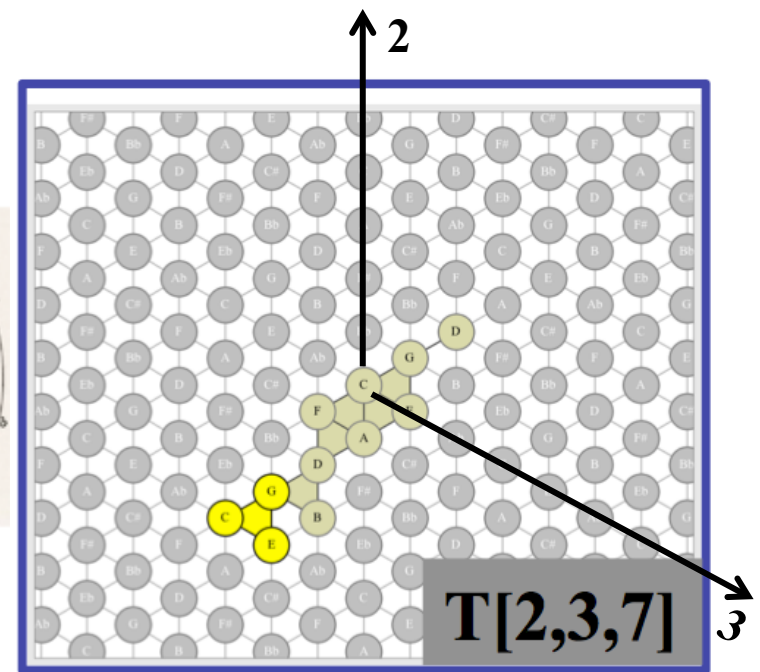
# Transformations géométriques de l'espace



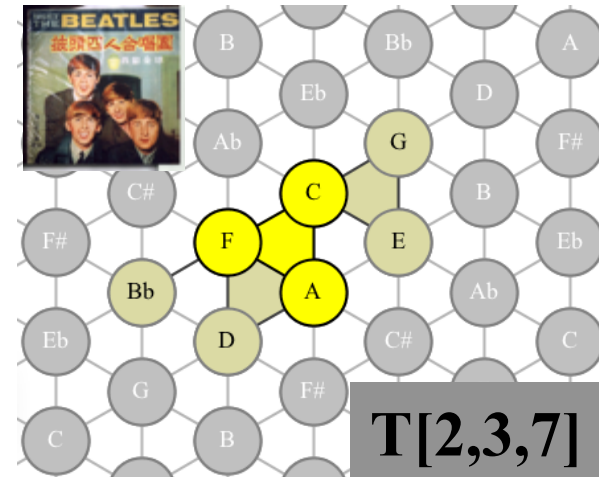
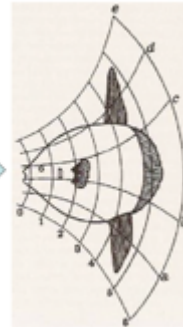
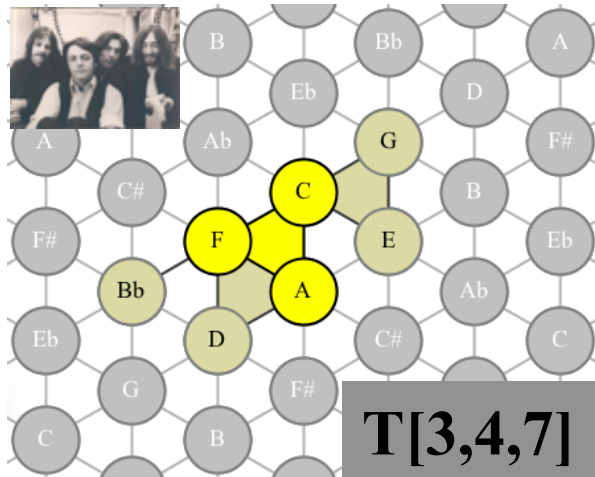
# Transformations géométriques de l'espace



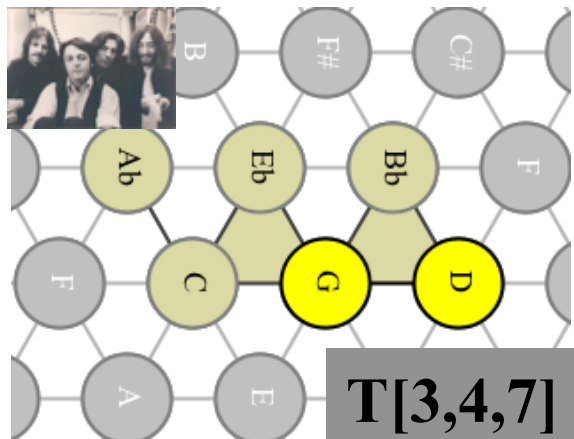
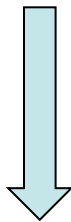
C. Lévi-Strauss



# Transformations stylistiques sur les Beatles



**M**



**M**

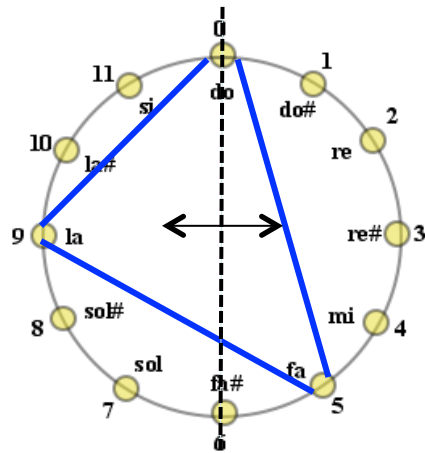


**M**

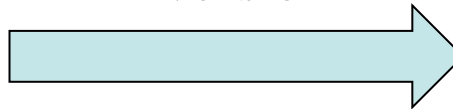


# Hey Jude, une version symétrique assistée par ordinateur

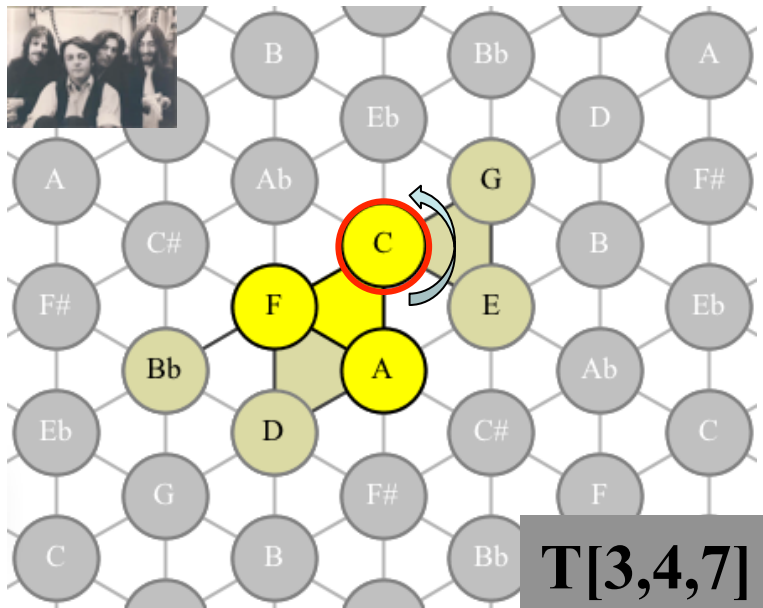
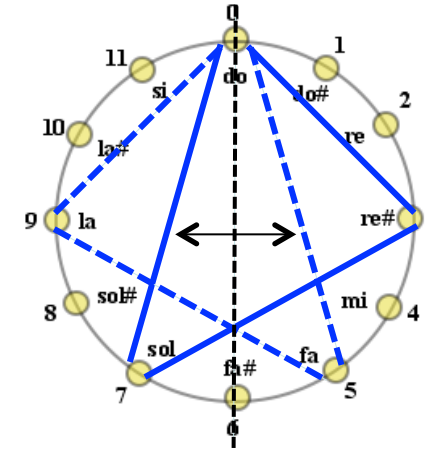
Accord  
de *Fa*  
majeur



inversion

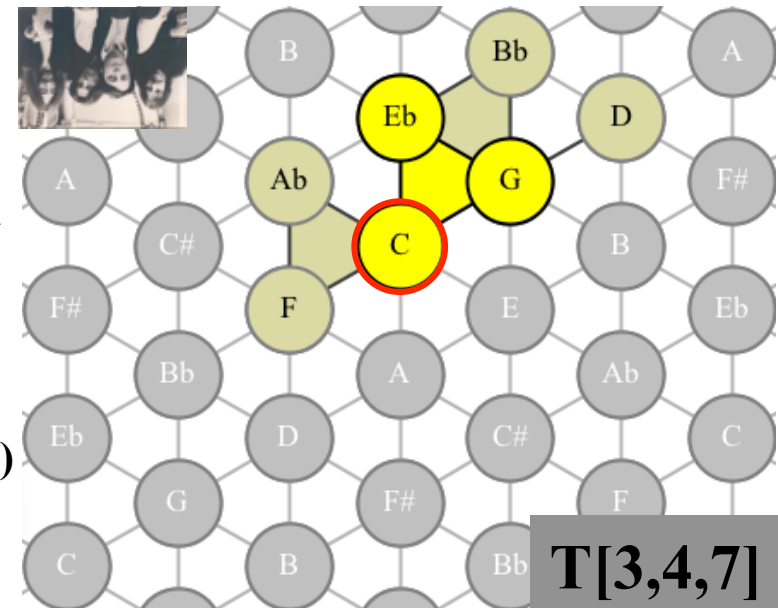


Accord  
de *do*  
mineur



Beatles, Hey Jude  
(version orig.)

Rotation  
(autour du do)



Beatles, Hey Jude  
(version transformée)

**Accord de Do majeur**

**inversion**

**Accord de fa mineur**



## Beatles, Hey Jude (version transformée)



**MERCI DE VOTRE ATTENTION !**

Moreno Andreatta

Equipe Représentations Musicales

IRCAM/CNRS UMR 9912