

Structural (Popular) Music Information Research

Some Theoretical, Analytical and Compositional Aspects

Moreno Andreatta

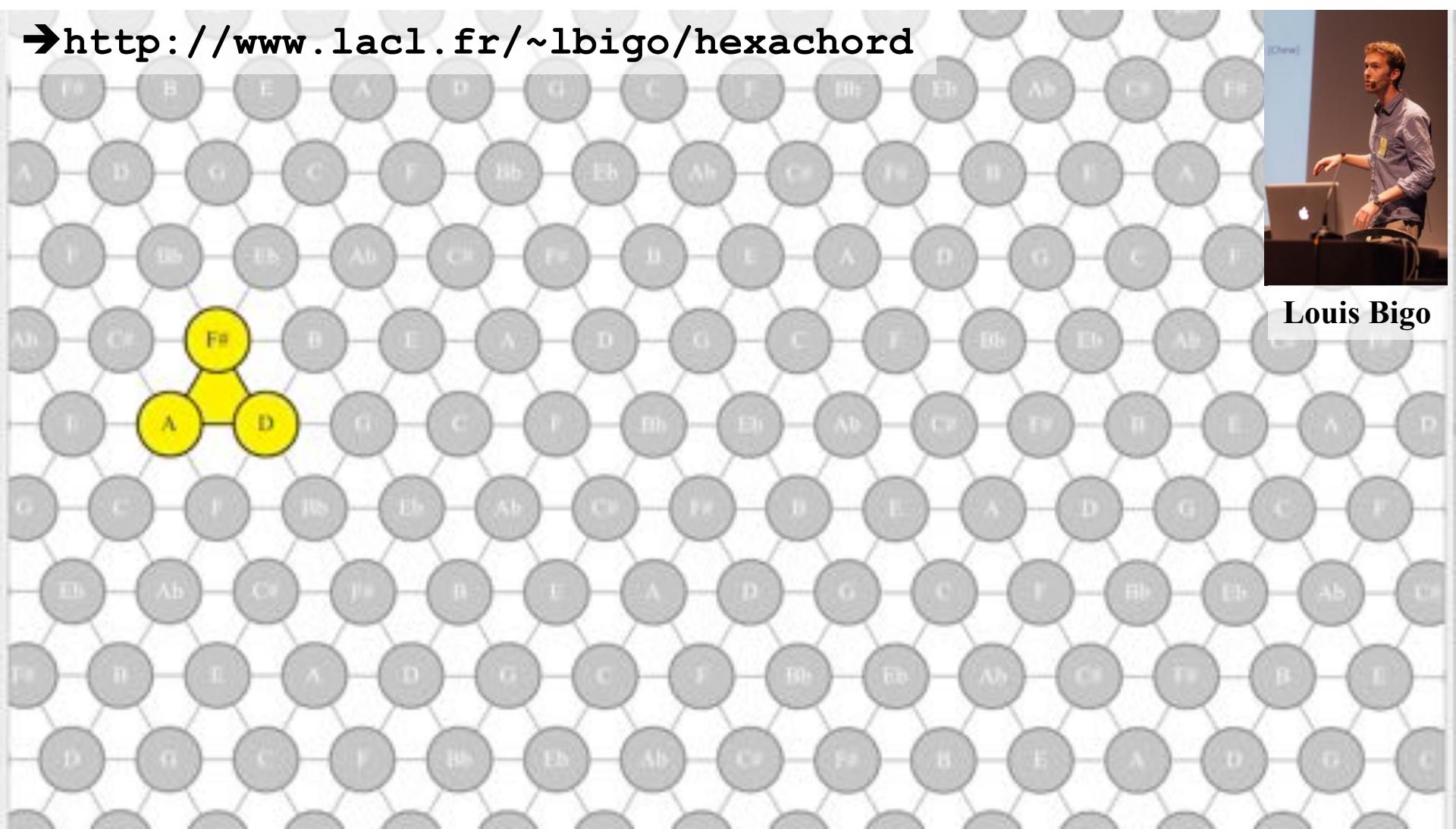
Music Representation Team

IRCAM/CNRS/Sorbonne University & IRMA/GREAM/USIAS

<http://repmus.ircam.fr/moreno/smri>

Symmetries and algorithmic processes in pop music

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

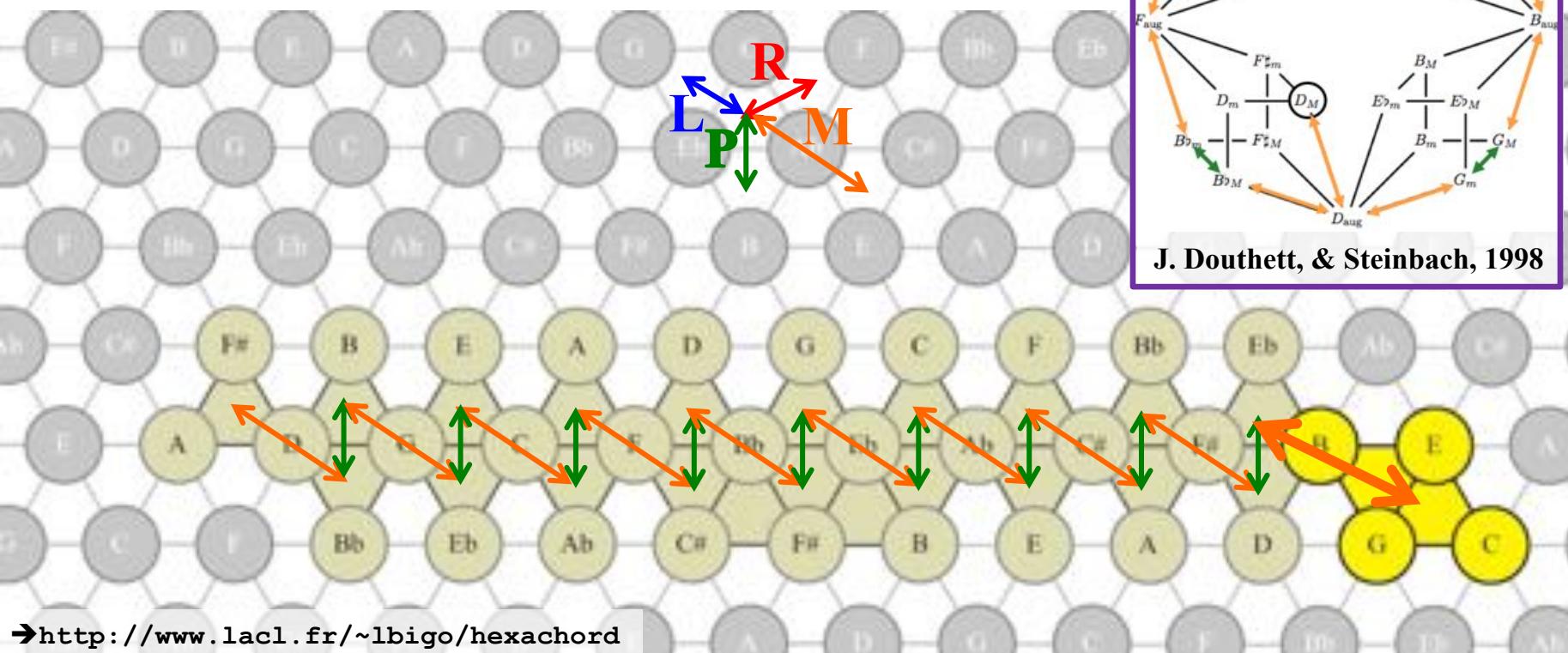


Louis Bigo

Symmetries and algorithmic processes in pop music



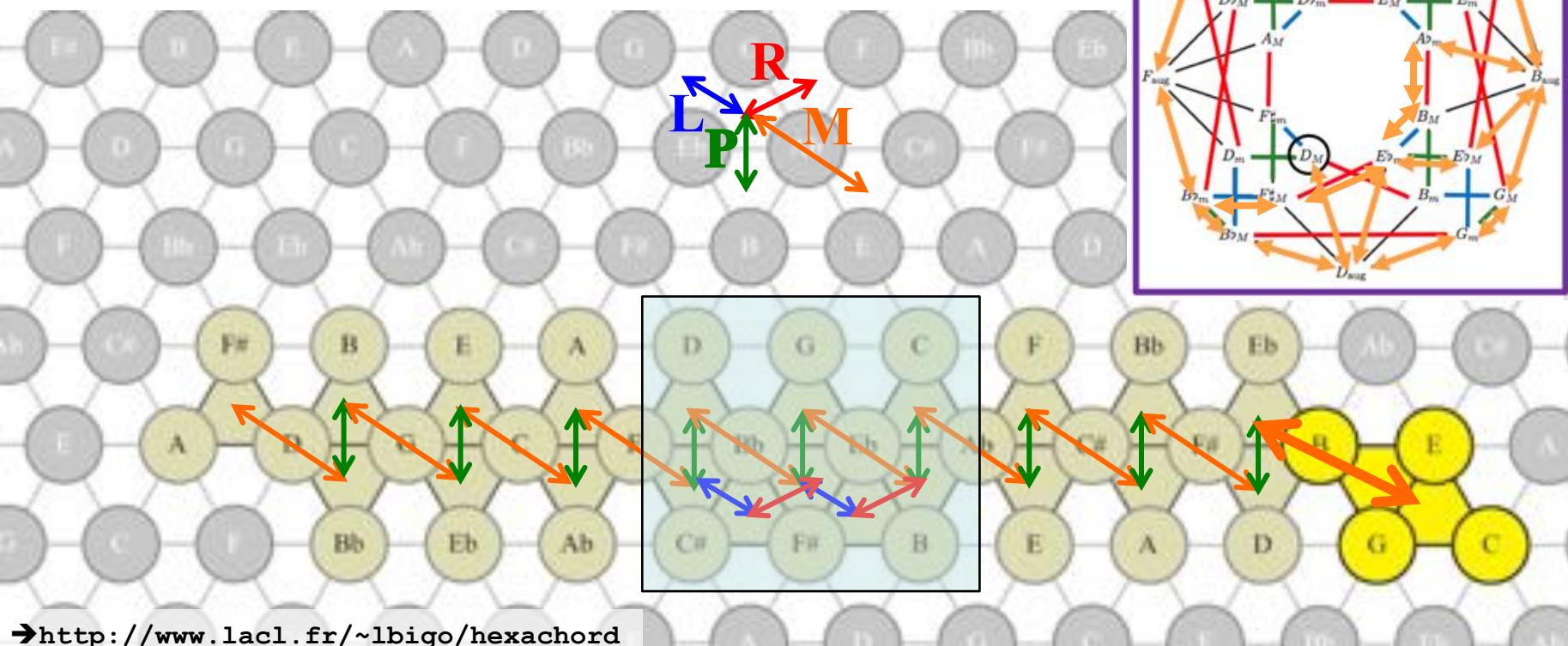
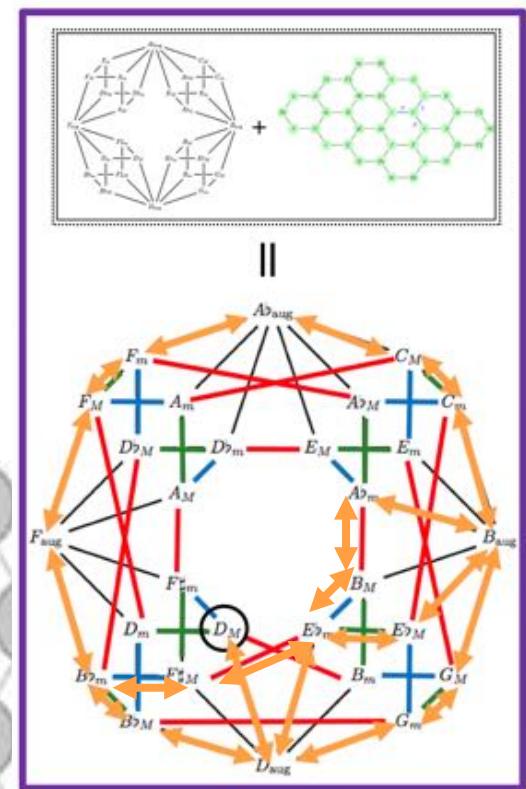
Muse, “Take a bow” (*Black Holes and Revelations*, 2006)



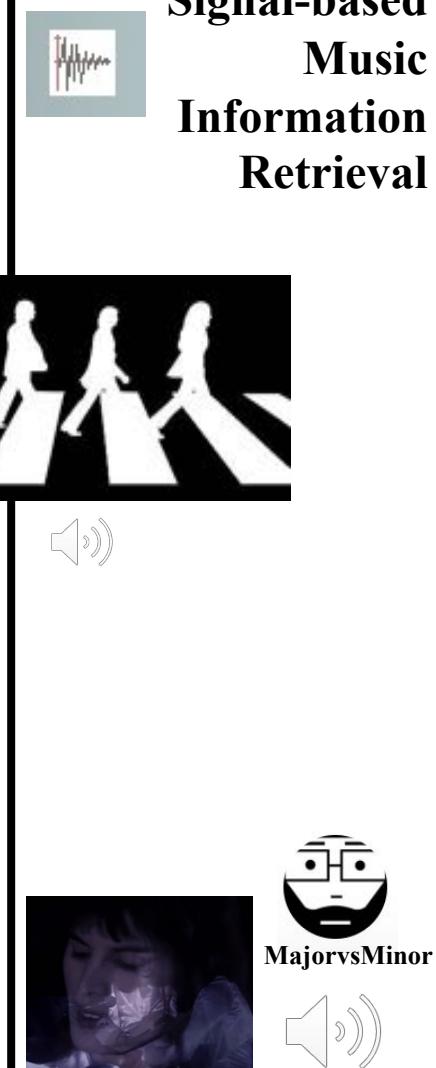
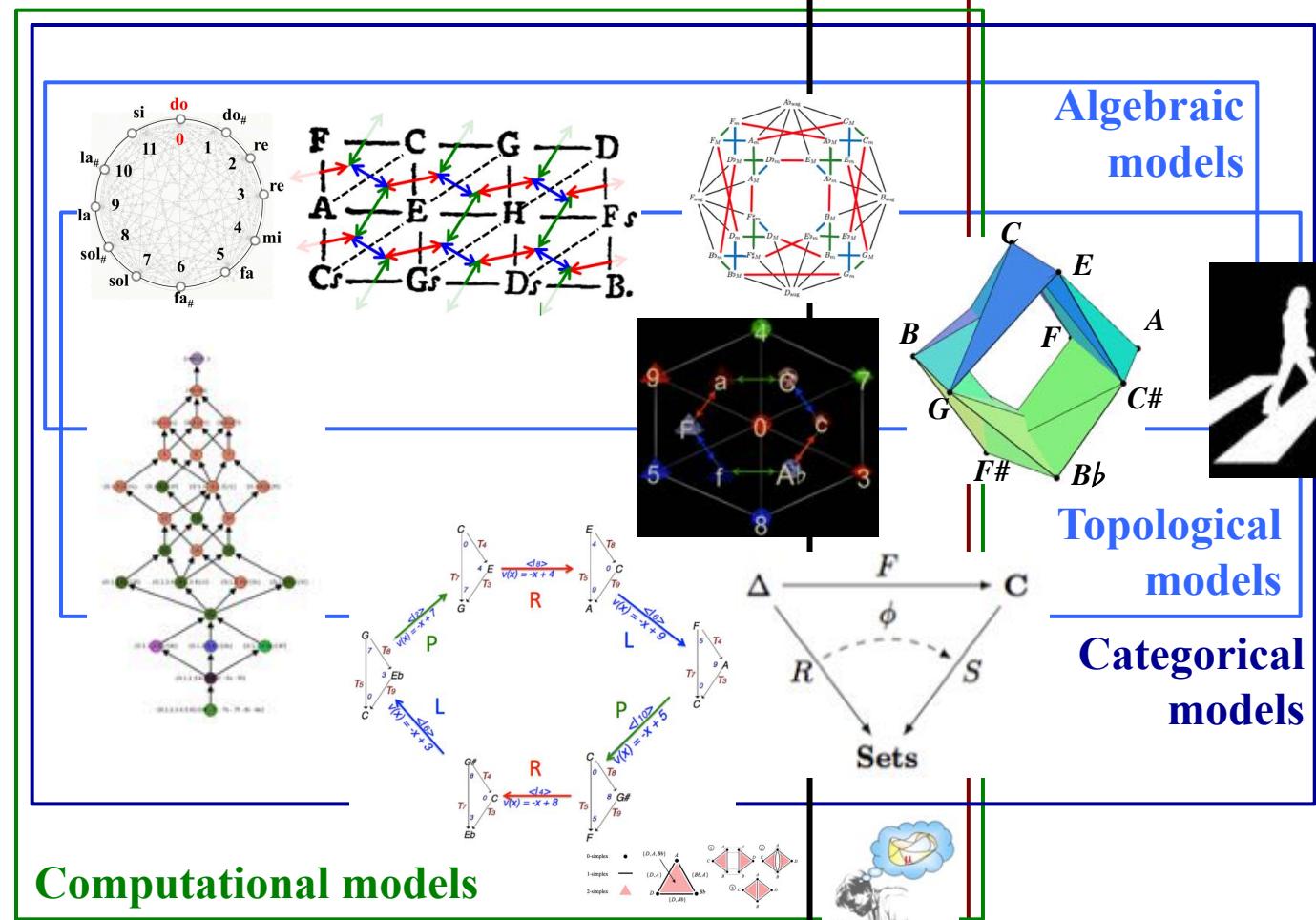
Symmetries and algorithmic processes in pop music



Muse, “Take a bow” (*Black Holes and Revelations*, 2006)

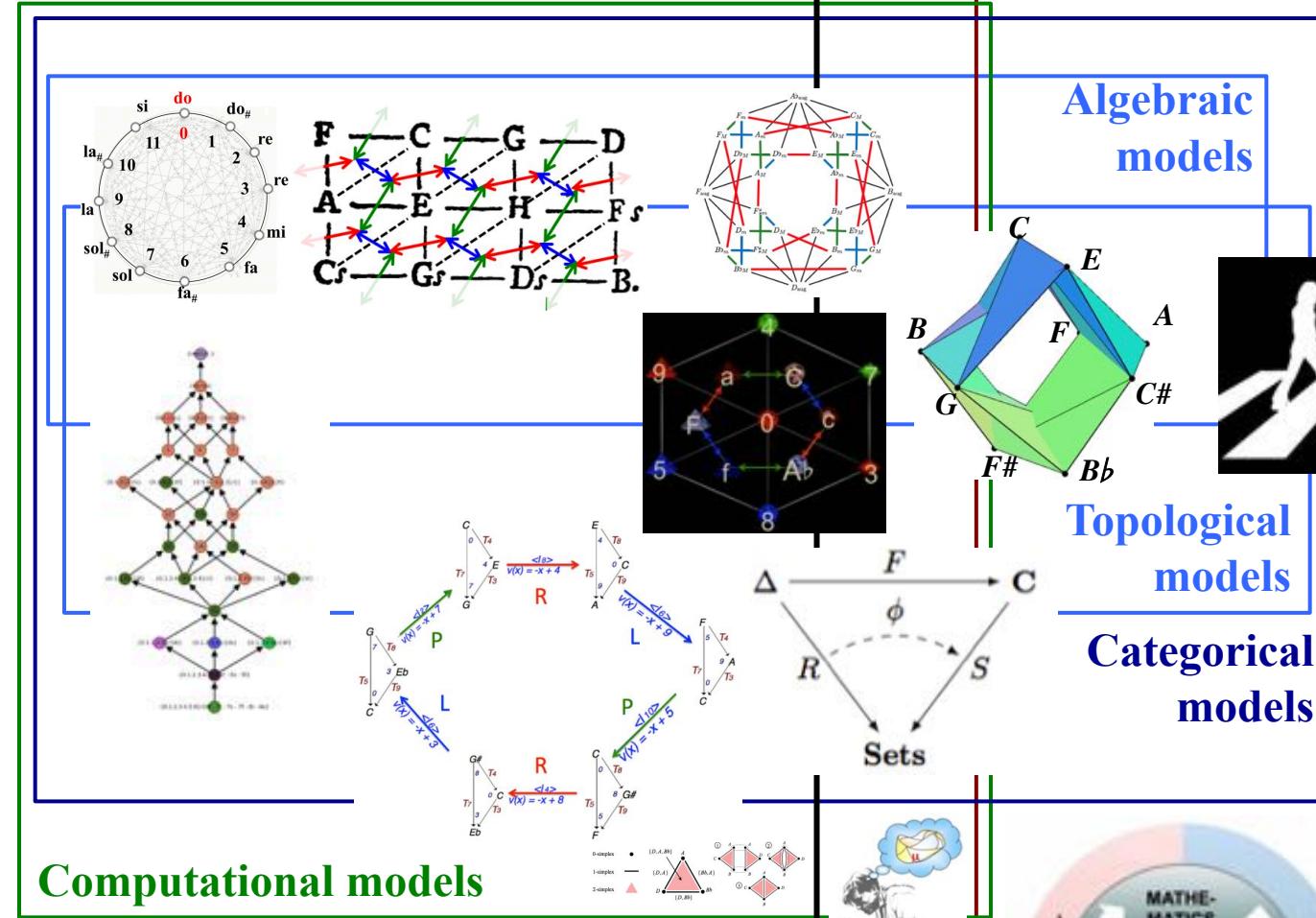


The SMIR Project: advanced maths for the working musicologist



Symbolic Music
Information Research

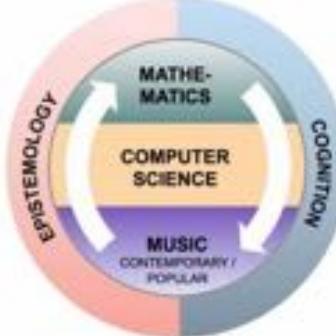
The SMIR Project: advanced maths for the working musicologist



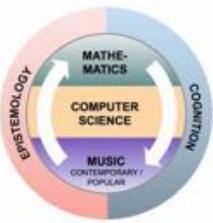
Signal-based
Music
Information
Retrieval



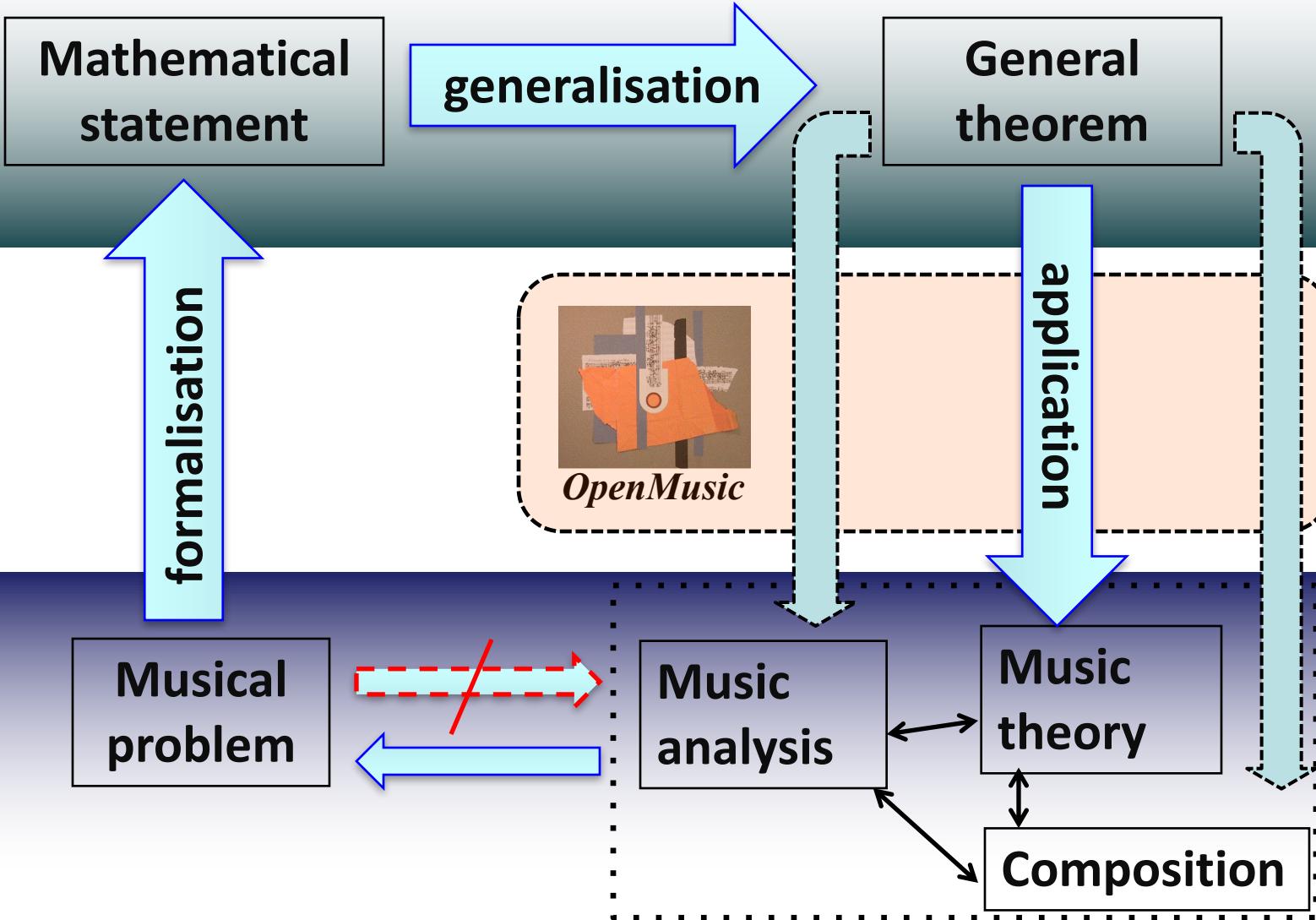
MajorvsMinor



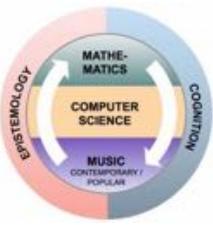
The double movement of a ‘mathemusical’ activity



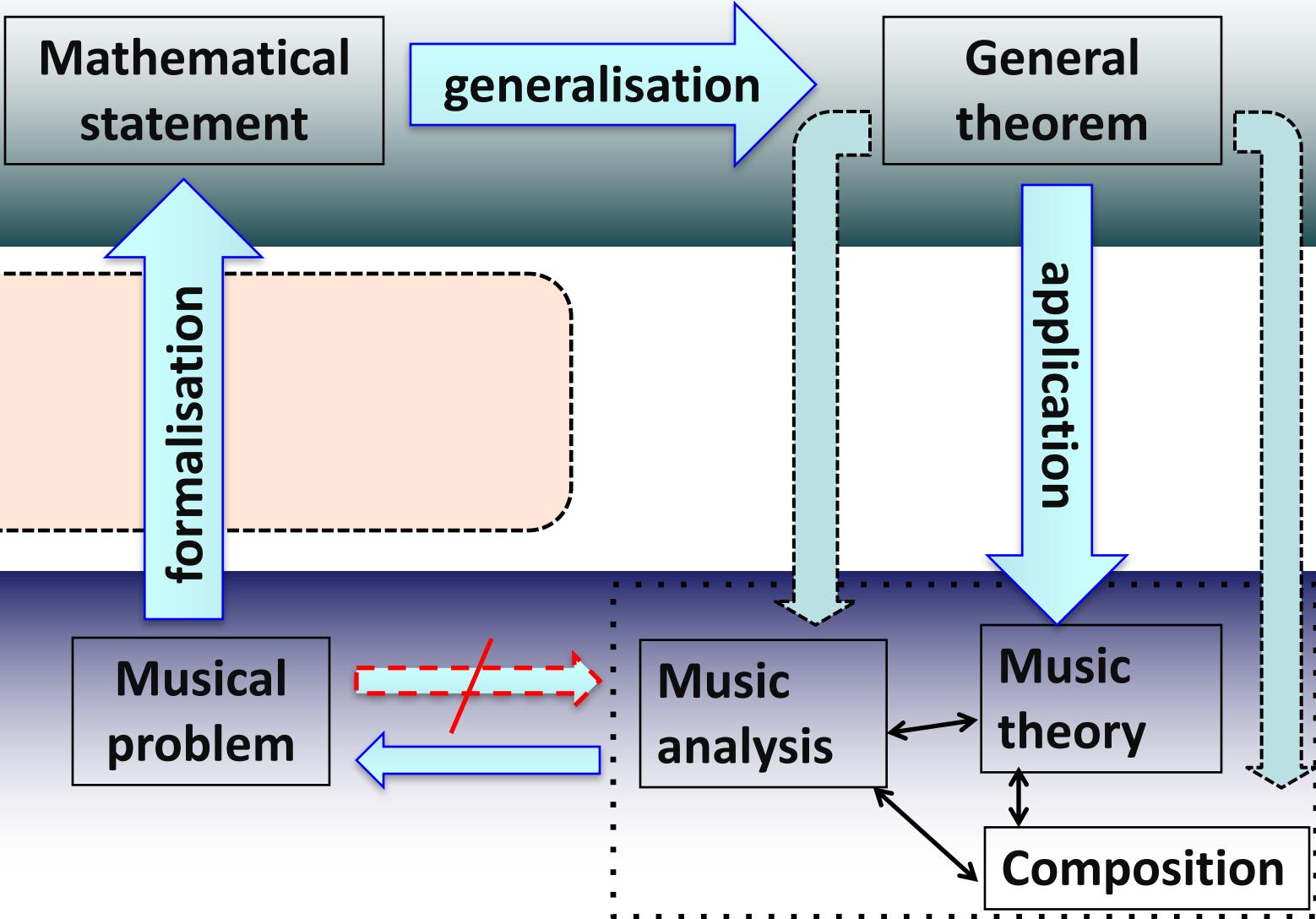
MATHEMATICS



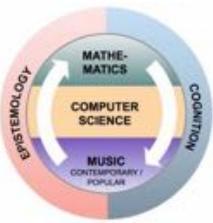
The double movement of a ‘mathemusical’ activity



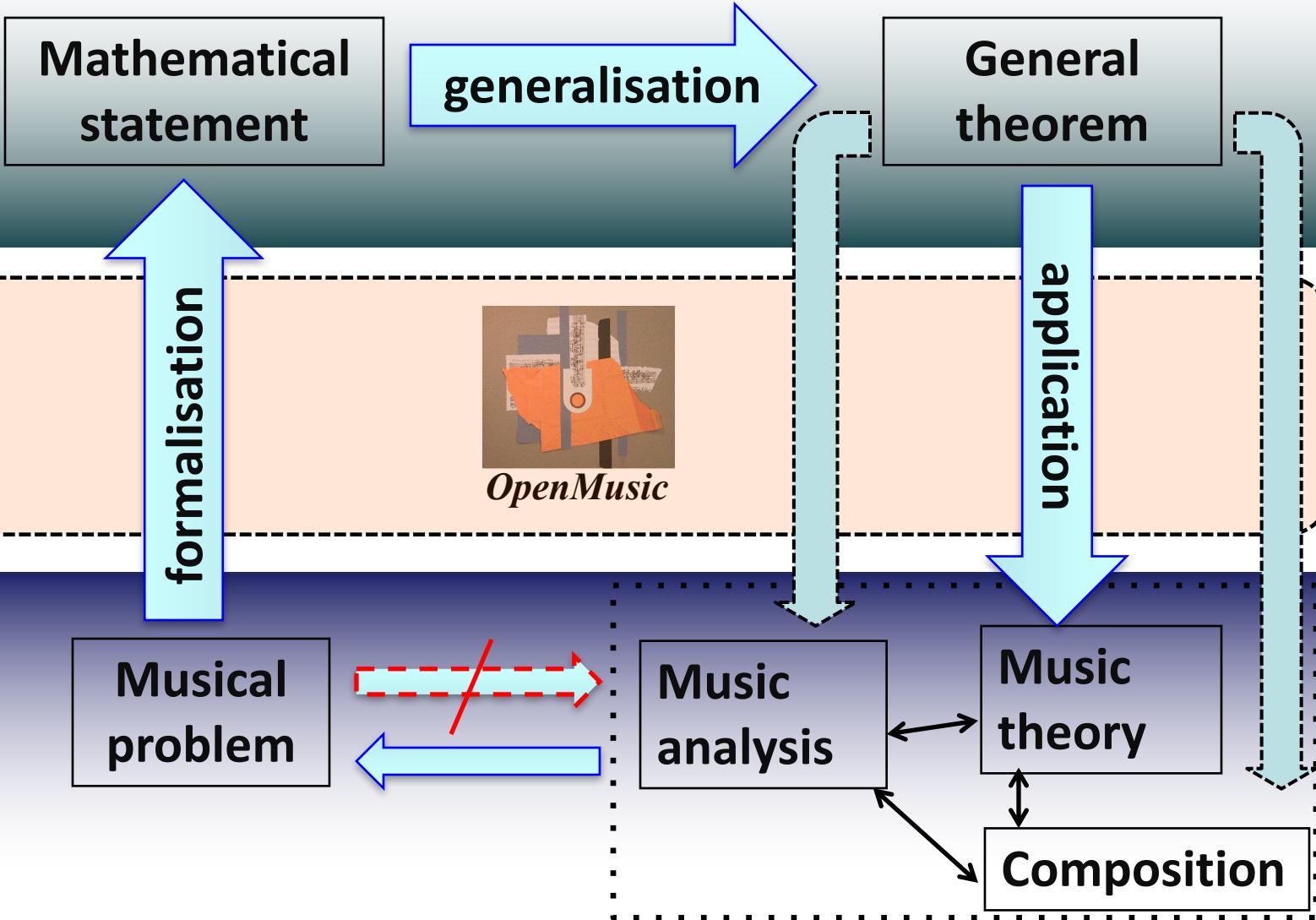
MATHEMATICS



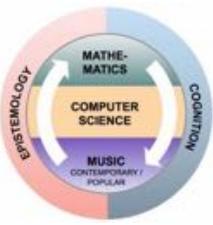
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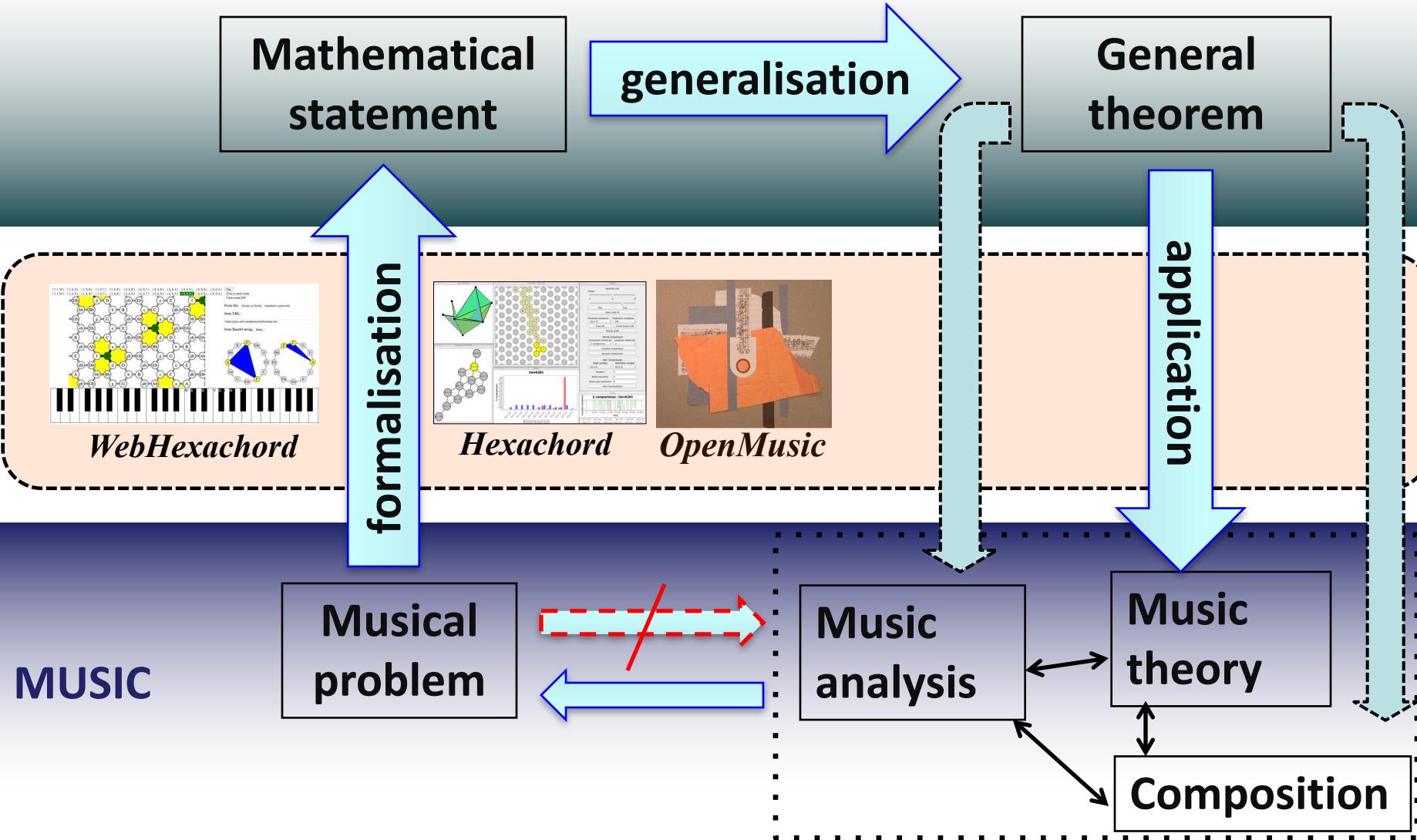
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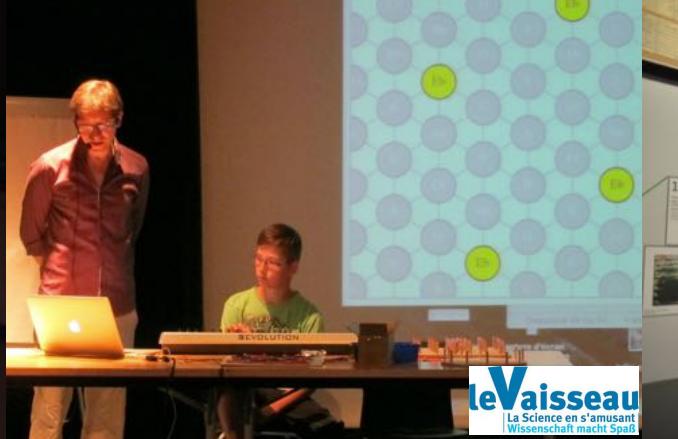
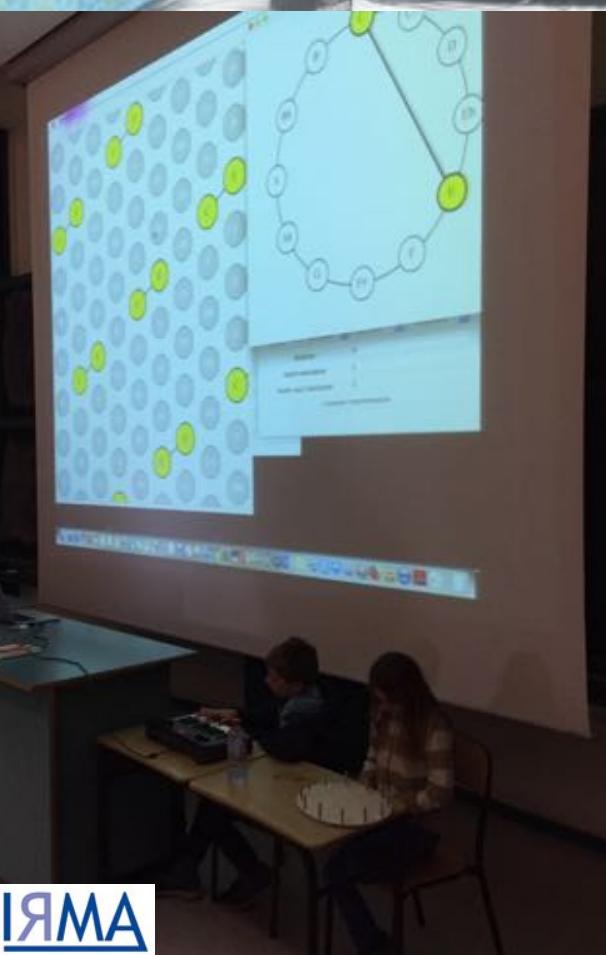


The double movement of a ‘mathemusical’ activity



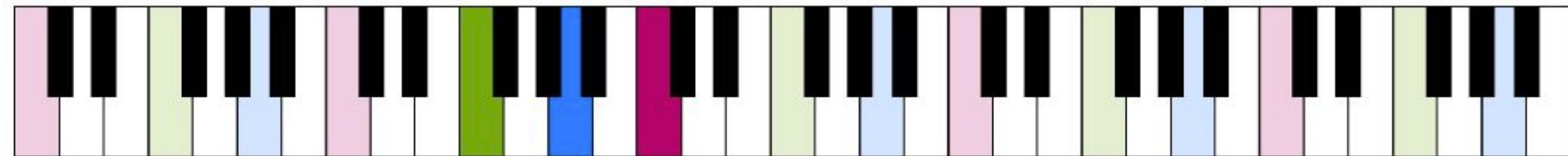
MATHEMATICS





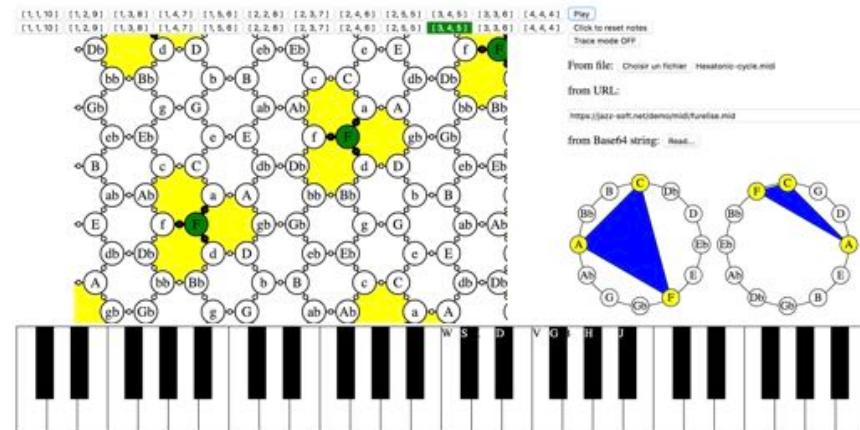


<https://imaginary.org/>



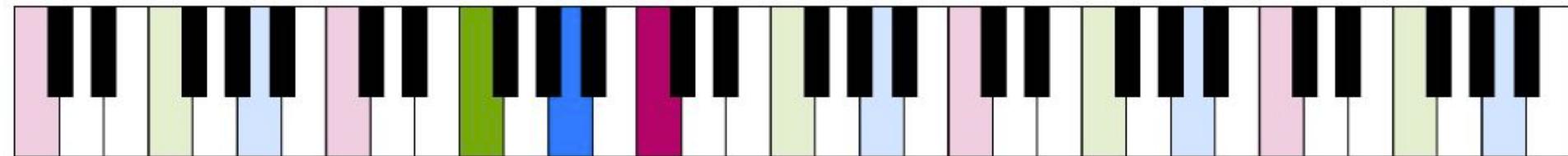
La.La.Lab brings the visitor to an interactive exploration and discovery of music from a mathematical perspective. The exhibition pivots over three axis:

- **Music theory.** Learning what tools build music, and how these tools are used to create art. Basic concepts and historical comments.
- **Current research.** The latest trends of research in the connection of maths and music. Artificial Intelligence, theoretical and new instruments, classification and composition tools.
- **Art and entertainment.** A joyful display of artworks from artists and mathematicians in the field. Talks/concerts at scheduled events



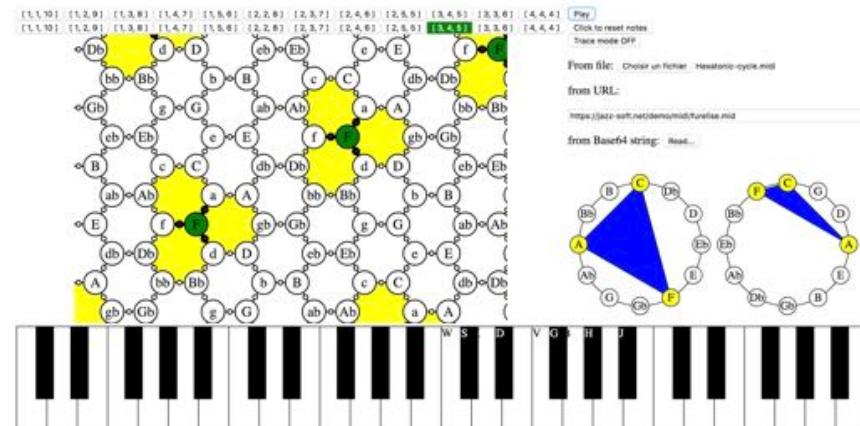


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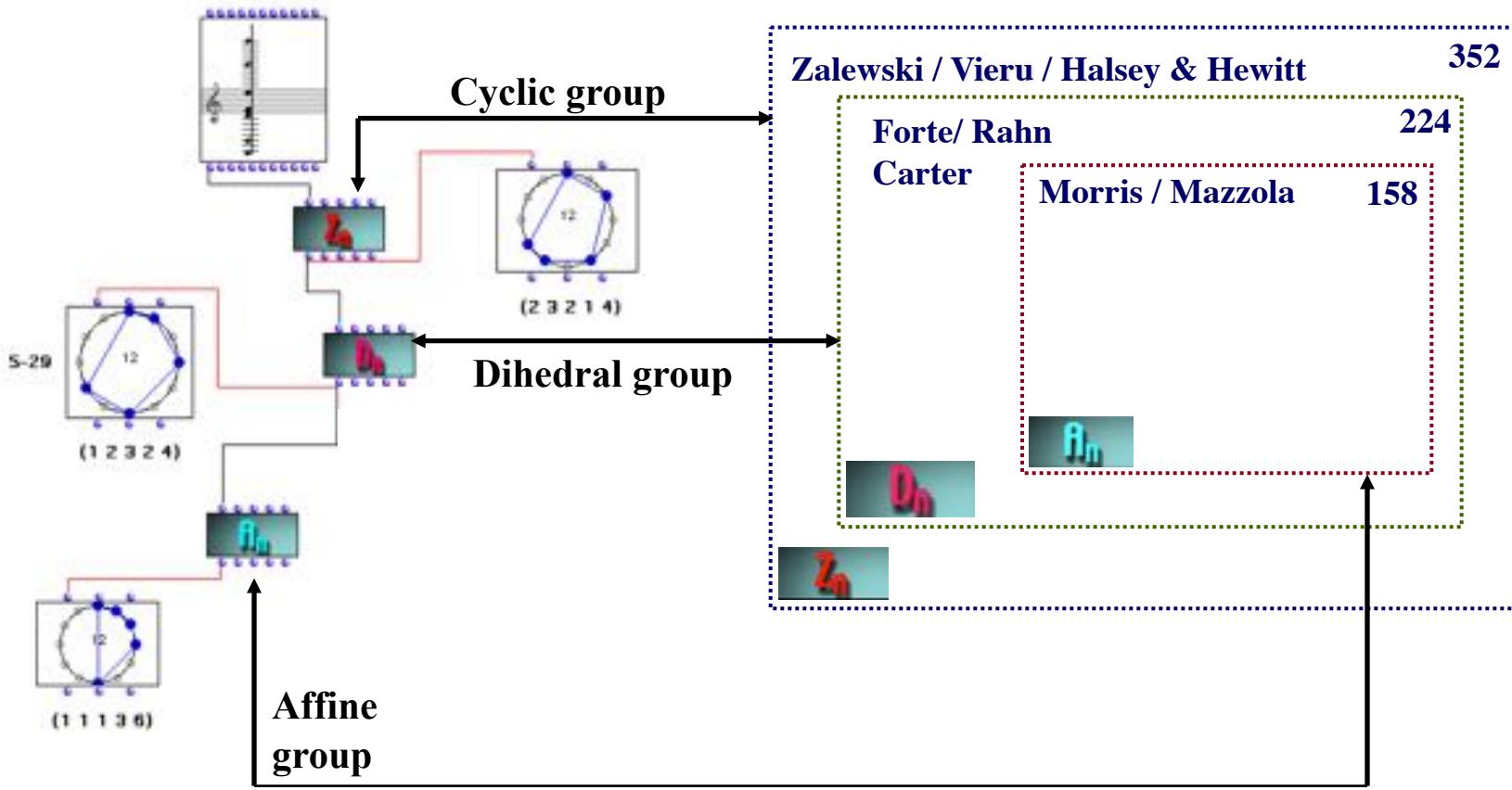
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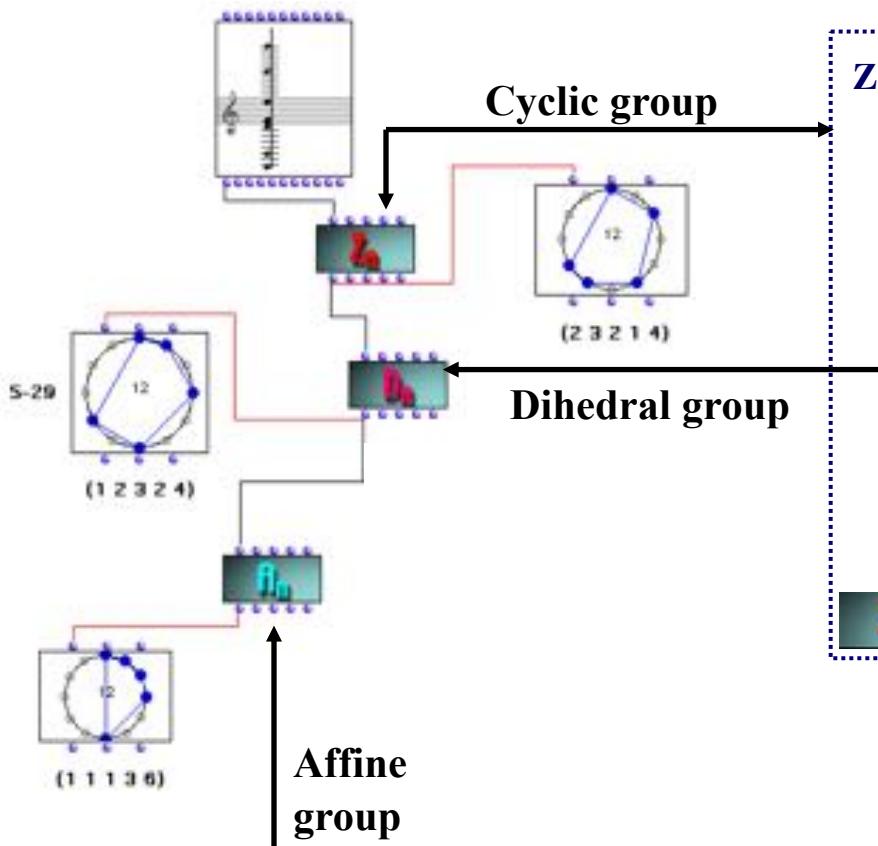
→ DEMO

Why are there twelve Tonnetze?



	1	2	3	4	5	6	7	8	9	10	11	12
Z_n	1	6	19	43	66	80	66	43	19	6	1	1
D_n	1	6	12	29	38	50	38	29	12	6	1	1
A_n	1	5	9	21	25	34	25	21	9	5	1	1

The interplay between Algebra and Geometry



Zalewski / Vieru / Halsey & Hewitt

352

Forte/ Rahn
Carter

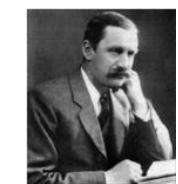
224

Morris / Mazzola

158



F. Klein



W. Burnside



G. Polya

The nature of a given geometry is [...] defined by the *reference* to a determinate group and the way in which spatial forms are related within that type of geometry. [Cf. *Felix Klein Erlangen Program - 1872*][...] We may raise the question whether there are any concepts and principles that are, although in different ways and different degrees of distinctness, necessary conditions for both the *constitution* of the **perceptual world** and the construction of the universe of **geometrical thought**. It seems to me that the **concept of group** and the **concept of invariance** are such principles.

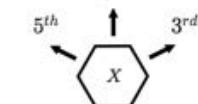
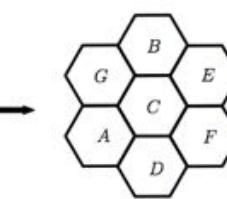
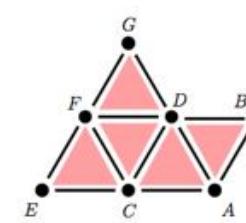
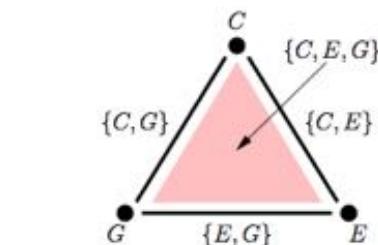
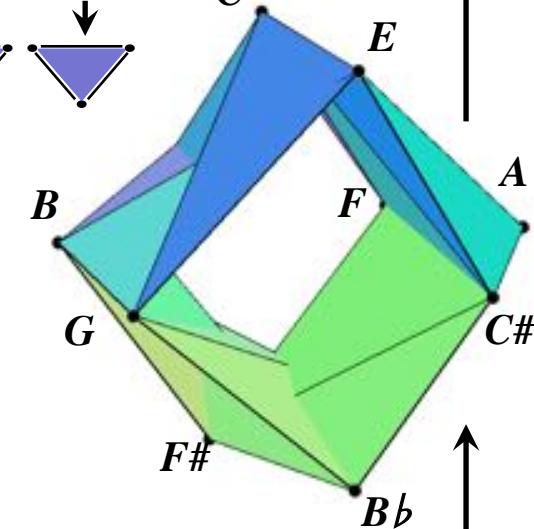
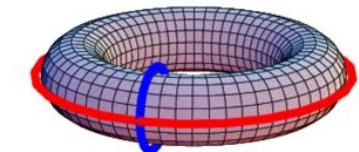
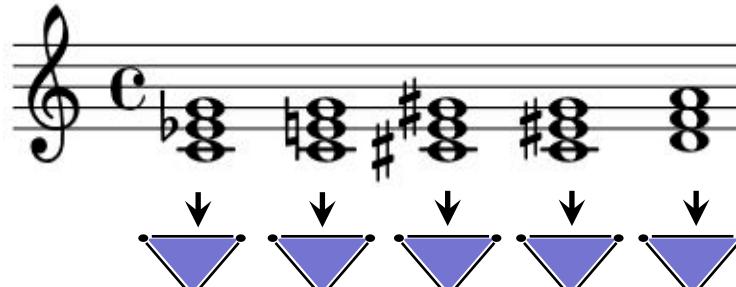
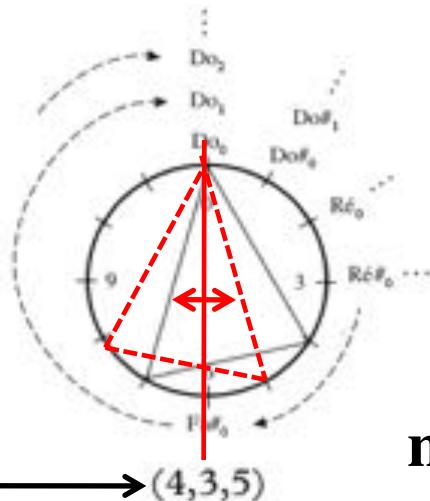


E. Cassirer

The interplay between Algebra and Topology

- Assembling chords related by some equivalence relation
 - Equivalence up to transposition/inversion:

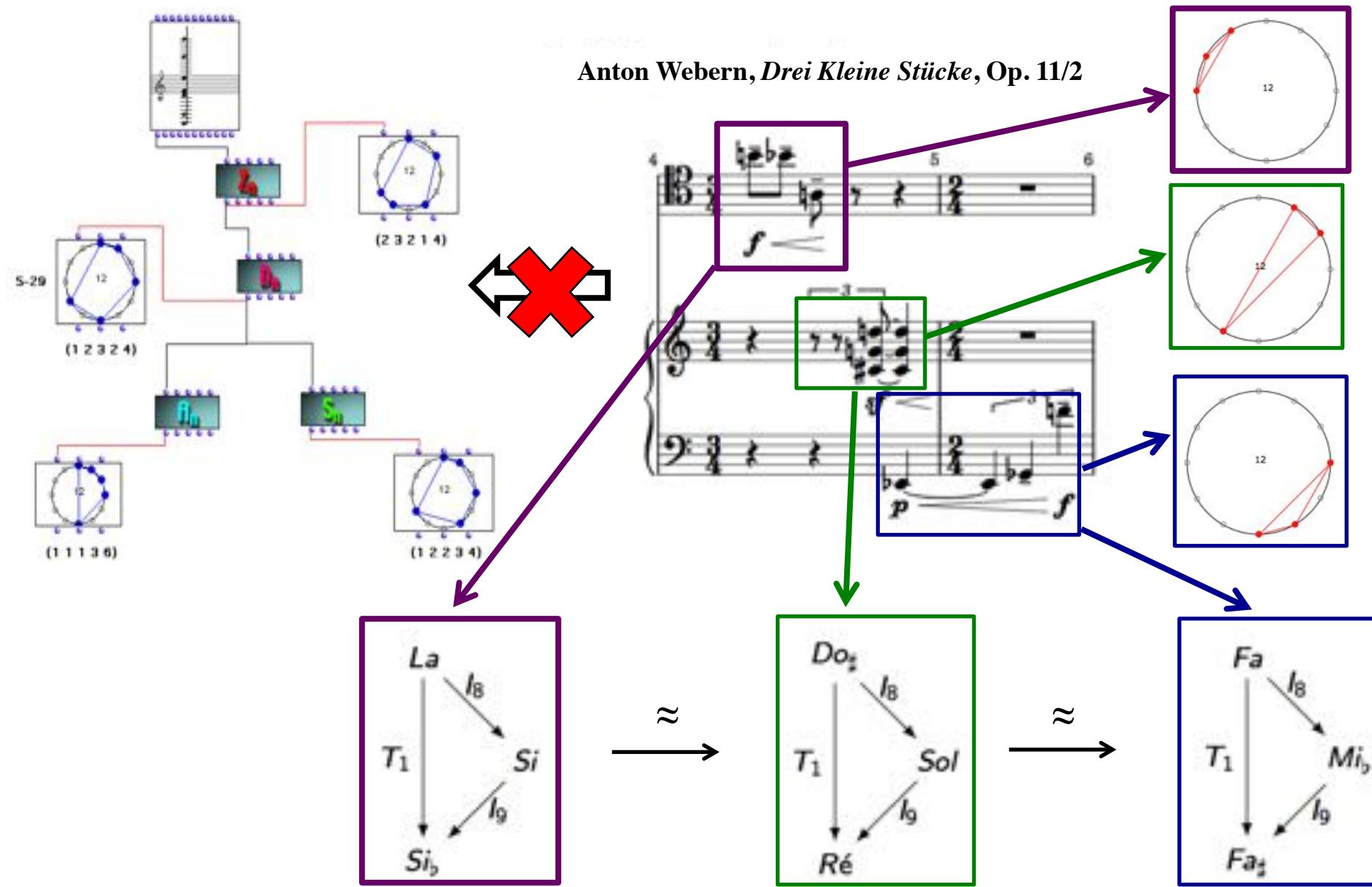
Intervallic
structure



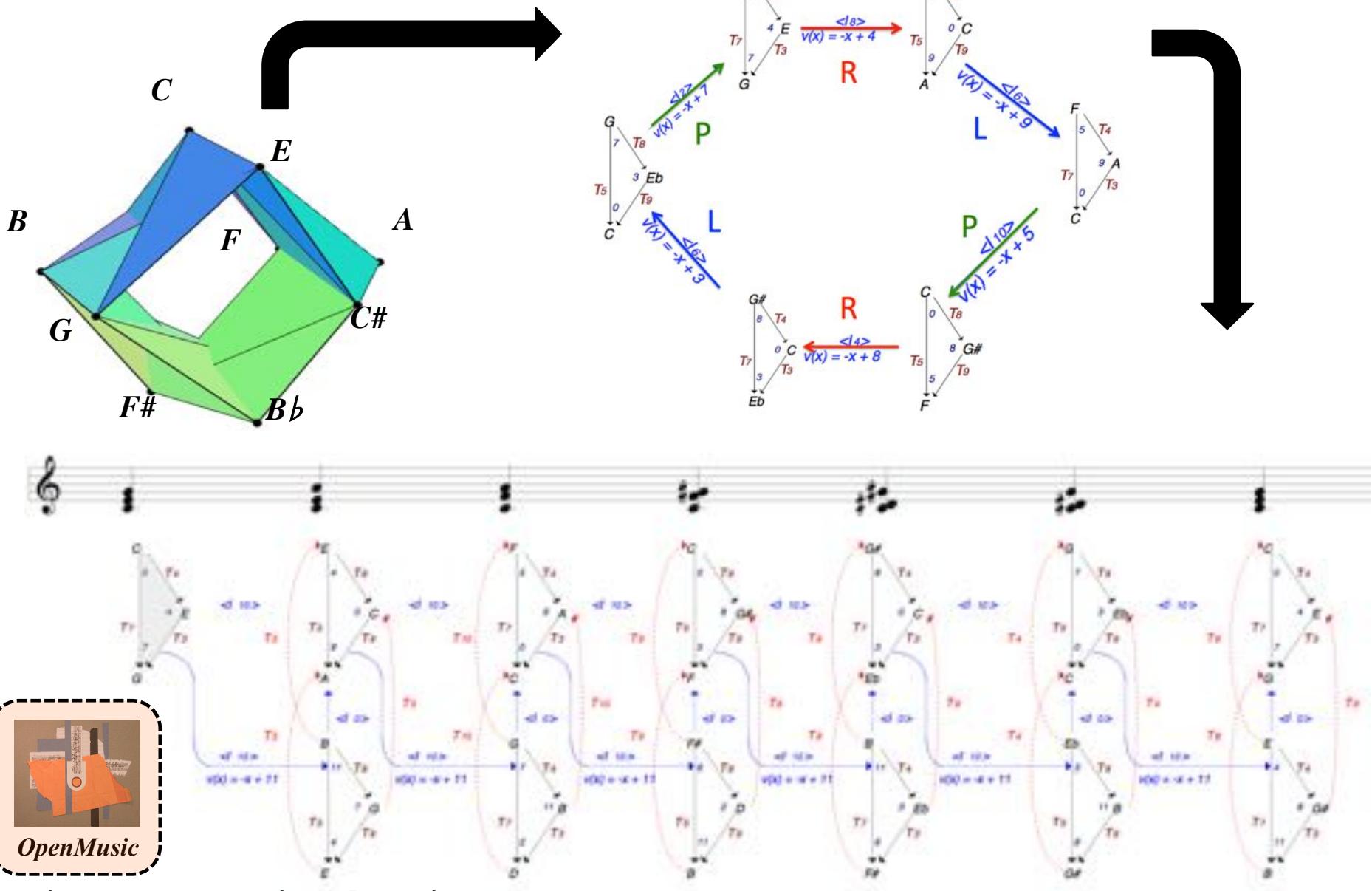
0-cell ● note
1-cell — 2-note chord

2-cell ▲ 3-note chord
3-cell ▲ 4-note chord

Why Category Theory for Music Analysis?

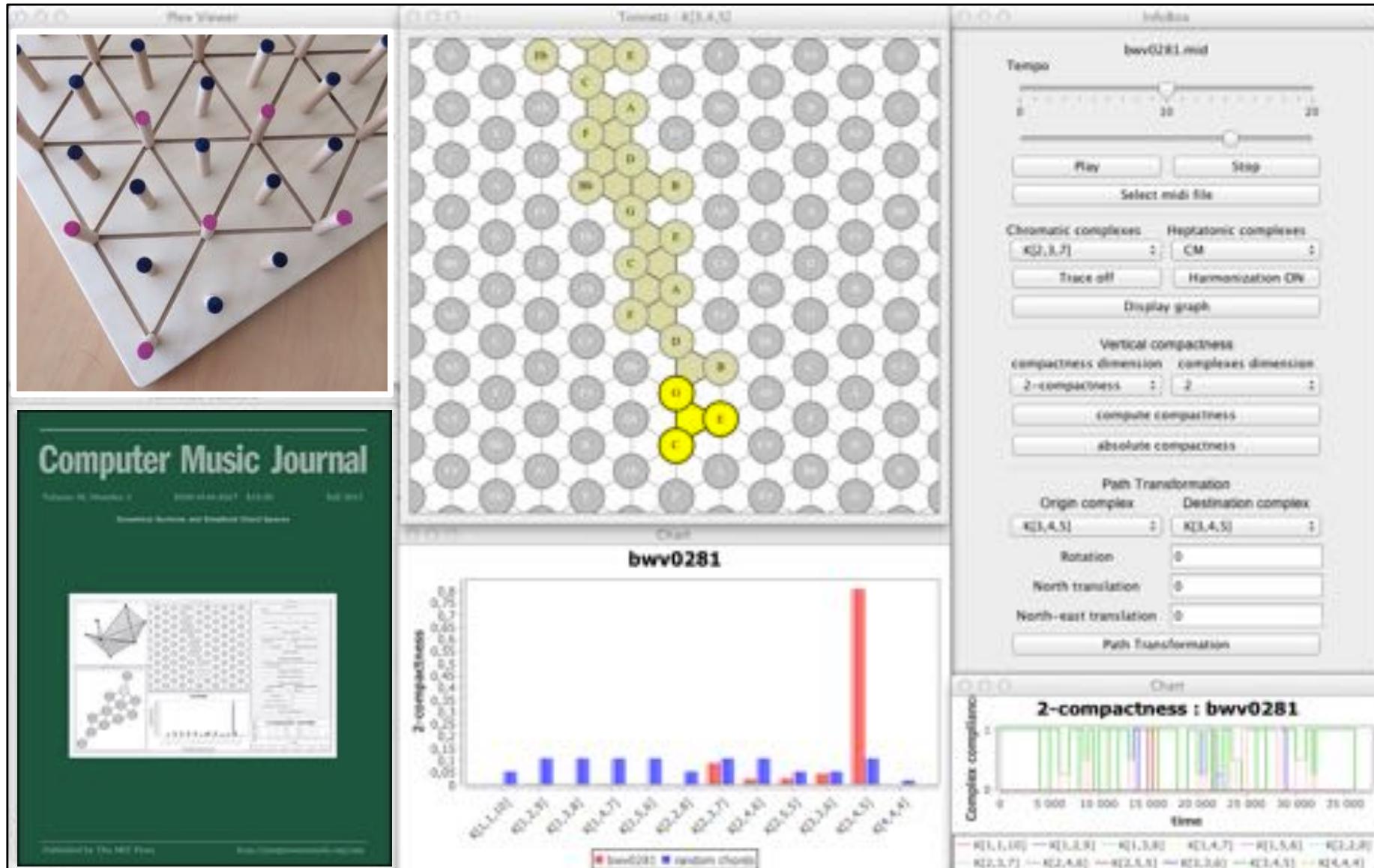


Mixing Algebra, Topology and Category Theory...



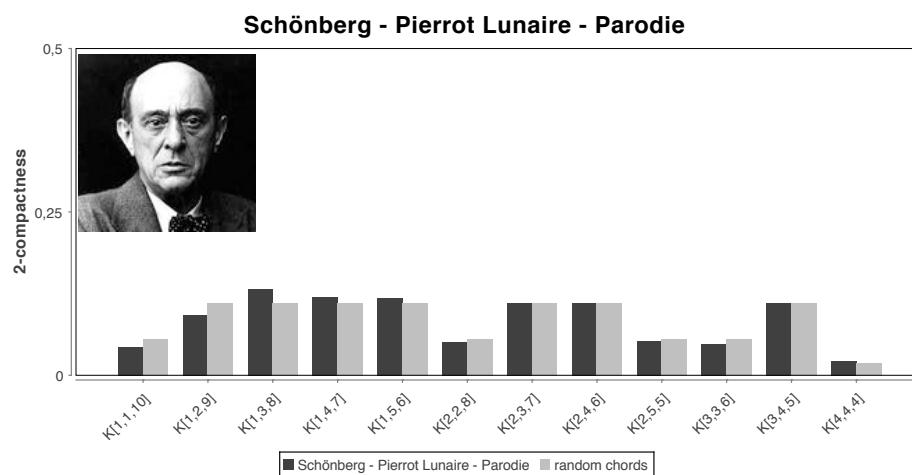
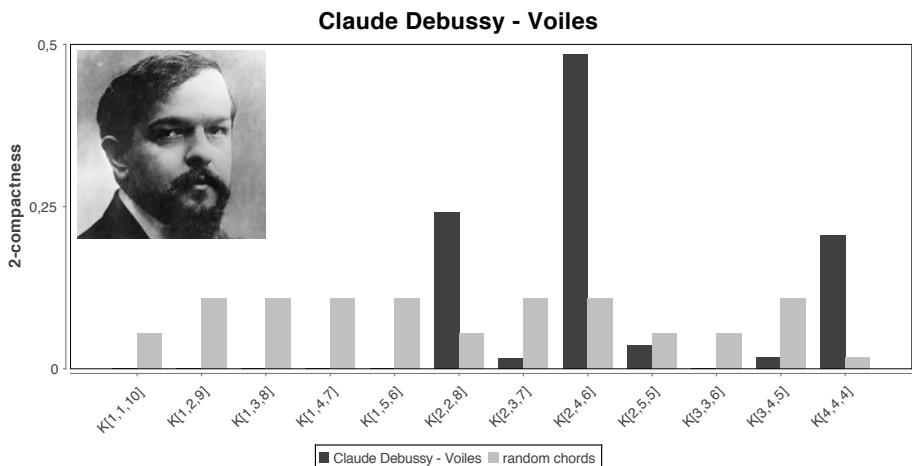
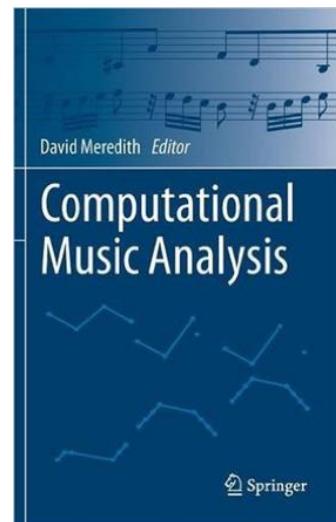
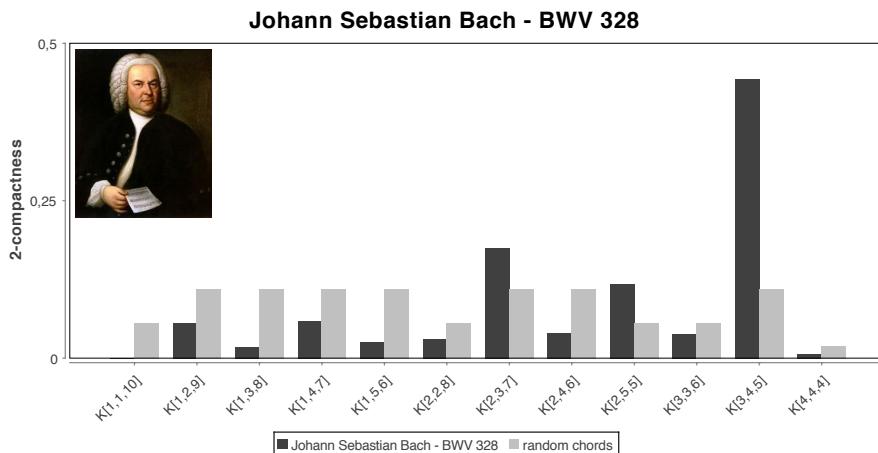
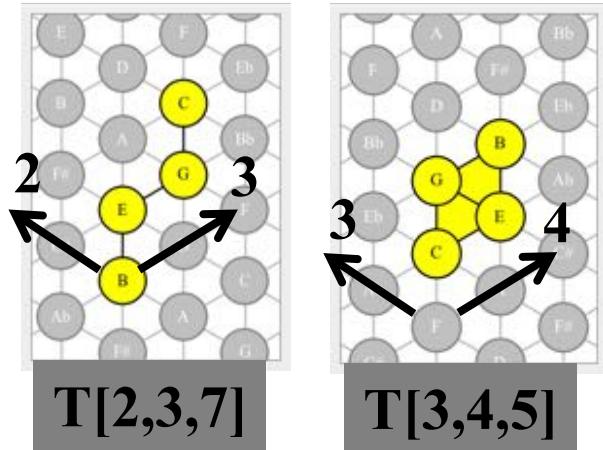
...in a computational environment

Towards a geometric-based stylistic classification

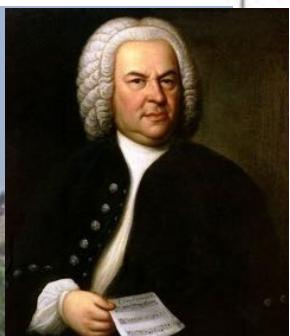
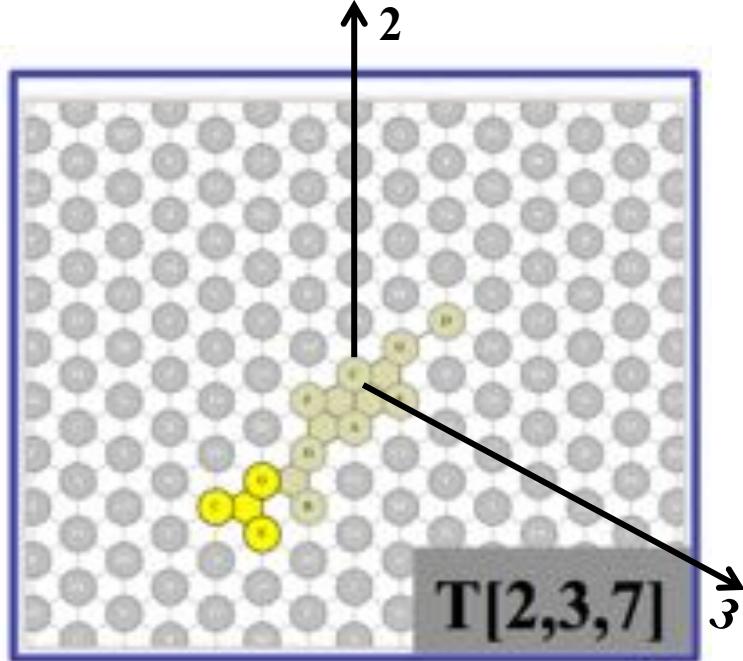
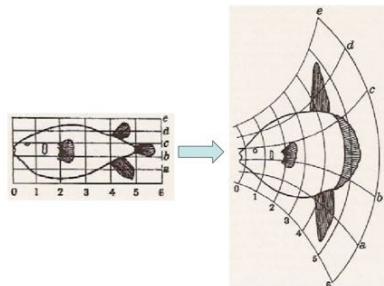
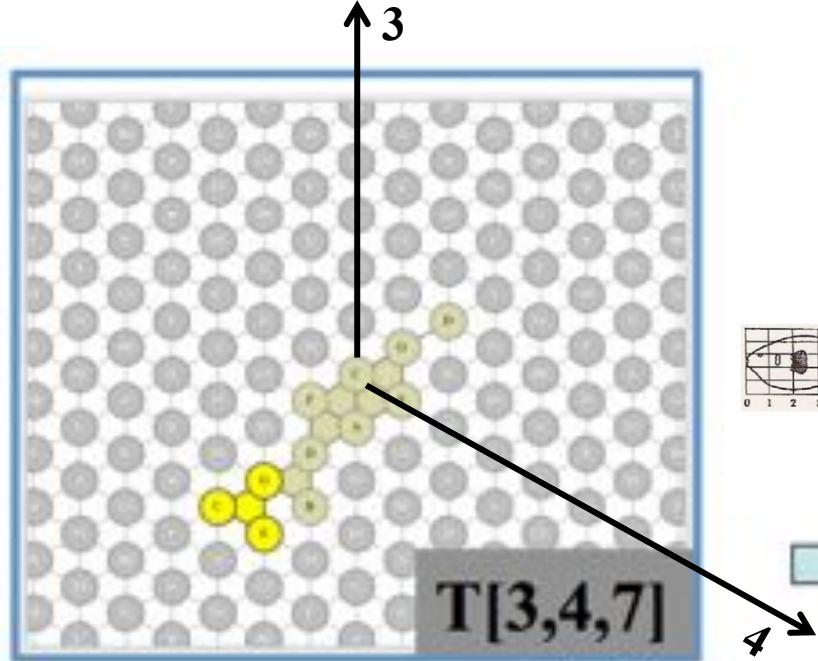


Bigo L., D. Ghisi, A. Spicher, M. Andreatta (2015), « Representation of Musical Structures and Processes in Simplicial Chord Spaces », *Computer Music Journal*, vol. 39, n. 3, p. 9-24, 2015.

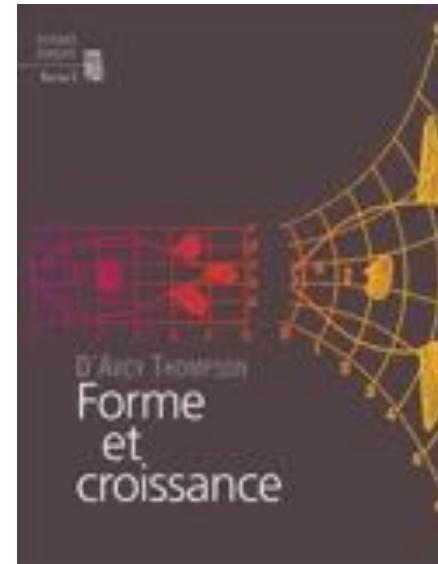
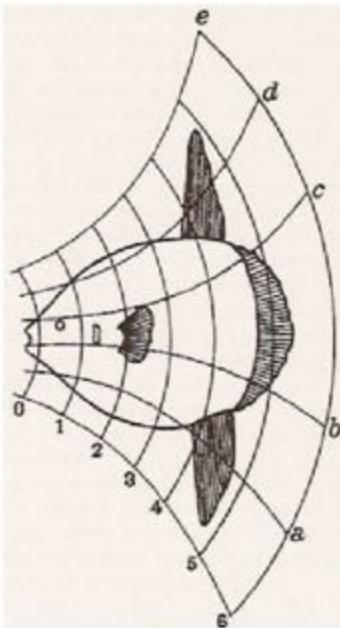
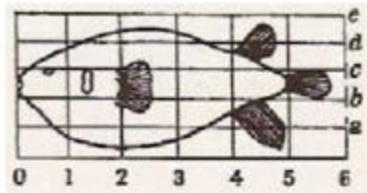
The geometric character of musical style



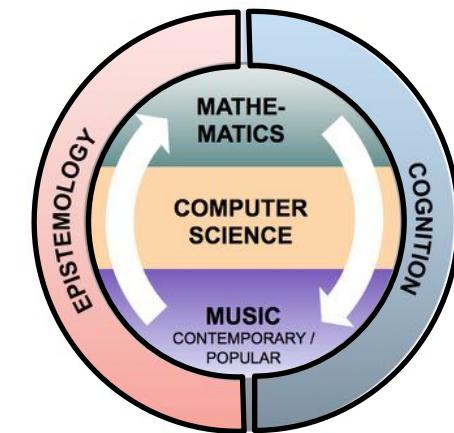
Embedding the trajectory into different spaces



The morphological genealogy of structuralism



“[The notion of **transformation**] comes from a work which played for me a very important role and which I have read during the war in the United States : *On Growth and Form*, in two volumes, by **D'Arcy Wentworth Thompson**, originally published in 1917. The author (...) proposes an interpretation of the visible transformations between the species (animals and vegetables) within a same gender. This was fascinating, in particular because I was quickly realizing that this perspective had a long tradition: behind Thompson, there was **Goethe**'s botany and behind Goethe, **Albert Dürer** with his *Treatise of human proportions*” (Lévi-Strauss, conversation with Eribon, 1988).



Keeping the space...but changing the trajectory!

The collage illustrates a musical transformation process. It starts with a wooden board game, moves to a hexachord diagram, then to a software interface, and finally to a visual representation of a famous song.

Top Left: A wooden board game with pegs on a hexagonal grid, representing a spatial arrangement of notes.

Top Middle: A hexachord diagram showing notes C, F, A, Eb, Bb, and D highlighted in yellow. A red circle highlights note C.

Top Right: A software interface for "Infras" showing a hexachord graph and various parameters like tempo and compactness. A red box highlights the "Path Transformation" section.

Bottom Left: The Beatles crossing Abbey Road.

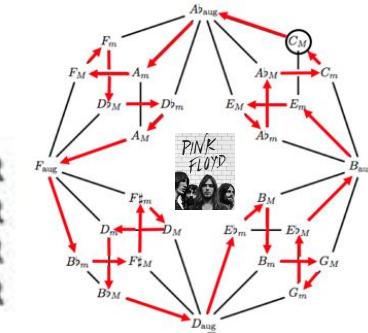
Bottom Middle: A red arrow points down from the top-middle hexachord diagram to the bottom-middle one, indicating a transformation or progression.

Bottom Right: A second hexachord diagram where the notes have been rearranged (Eb, Ab, G, C, F, Bb) while note C remains highlighted.

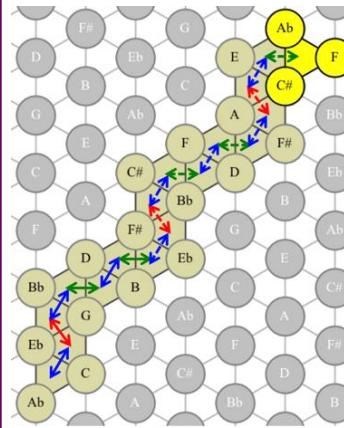
→ <http://www.lacl.fr/~lbigo/hexachord>

Exploring Hamiltonian trajectories in song writing

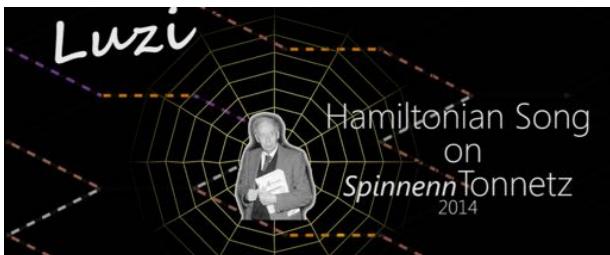
1. C-Cm-Ab-Abm-E-C#m-A-Am-F-Fm-C#-Bbm-F#-F#m-D-Dm-Bb-Gm-Eb-Ebm-B-Bm-G-Em--PLPLRL
2. C-Cm-Ab-Fm-C#-C#m-A-Am-F-Dm-Bb-Bbm-F#-F#m-D-Bm-G-Gm-Eb-Ebm-B-Abm-E-Em--PLRLPL
3. C-Cm-Eb-Ebm-F#-F#m-A-C#m-E-Em-G-Gm-Bb-Bbm-C#-Fm-Ab-Abm-B-Bm-D-Dm-F-Am--PRPRPRLR
4. C-Cm-Eb-Ebm-F#-Bbm-C#-C#m-E-Em-G-Gm-Bb-Dm-F-Fm-Ab-Abm-B-Bm-D-F#m-A-Am--PRPRLRPR
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--PRLRPLR
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-Ed-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--RPRPRLRP
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--RPRRLRLP
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



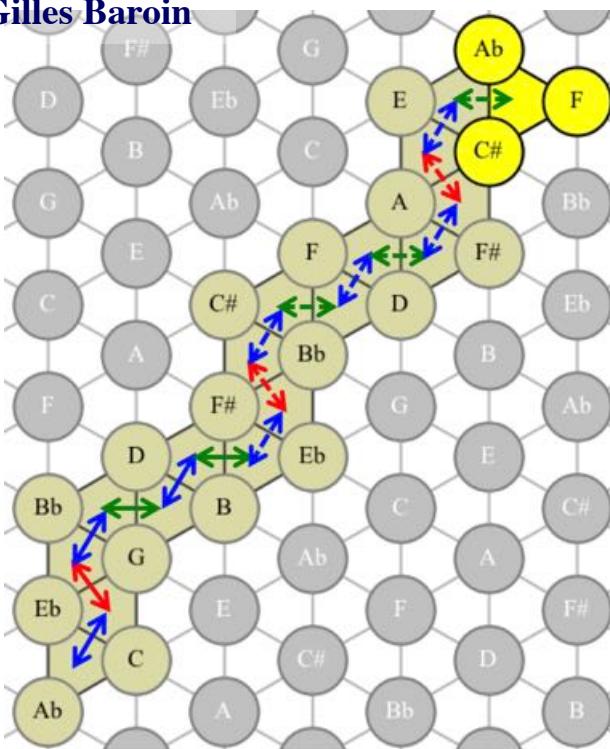
LPLPLR...
PLPLRL...
LPLRLP...
PLRLPL...
RLRLPLP...



La sera non è più la tua canzone (after Mario Luzi)



Gilles Baroin

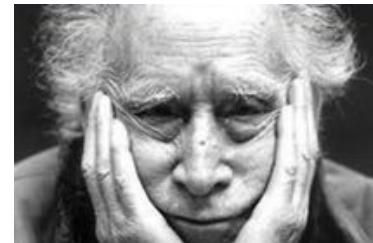


**La sera non è più la tua canzone,
è questa roccia d'ombra traforata
dai lumi e dalle voci senza fine,
la quiete d'una cosa già pensata.**

**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.**



M. Luzi (1914-2005)

*Le soir n'est plus ta chanson,
c'est ce rochet d'ombre transpercé
par les lumières et les voix sans fin,
la paix d'une chose déjà pensée.*

*Ah, cette lumière vive et claire vient
uniquement de toi, tu es si proche
du vrai d'une chose connue,
tu as pour nom une parole qui est passée
dans l'intimité du cœur où elle s'est
perdue .*

*Tombé est plus qu'un signe de la vie,
tu te reposes, du voyage tu es revenue
à l'intérieur de toi même, tu es
descendue dans cette
pure substance qui est si tienne,
si éloignée
dans le silence de l'être, achevée.*

*L'air se tait et le temps derrière toi
se lève tel une montagne aride
où plane ton esprit et se perd,
un vent rare glisse et stagne.*

(tr. Antonia Soulez, philosophe et poète)

Music: M. Andreatta
Arrangement and mix: M. Bergomi & S. Geravini
(Perfect Music Production)
Mastering: A. Cutolo (Massive Arts Studio, Milan)



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