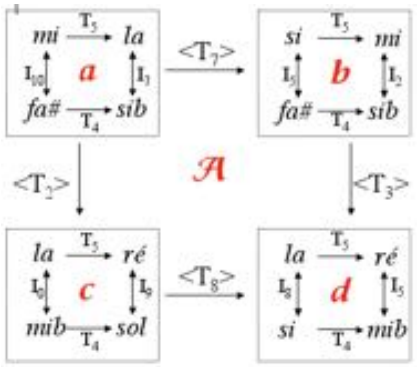
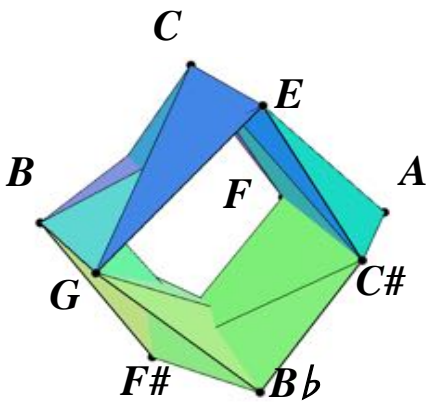
Exploring the "mathemusical" dynamics: some aspects of a musically driven mathematical practice





Istituto Veneto di
Lettere Scienze e Arti

March 31, 2017

Moreno Andreatta
Music Representations Team
IRCAM/CNRS/UPMC & IRMA/USIAS Strasbourg
http://www.ircam.fr/repmus.html

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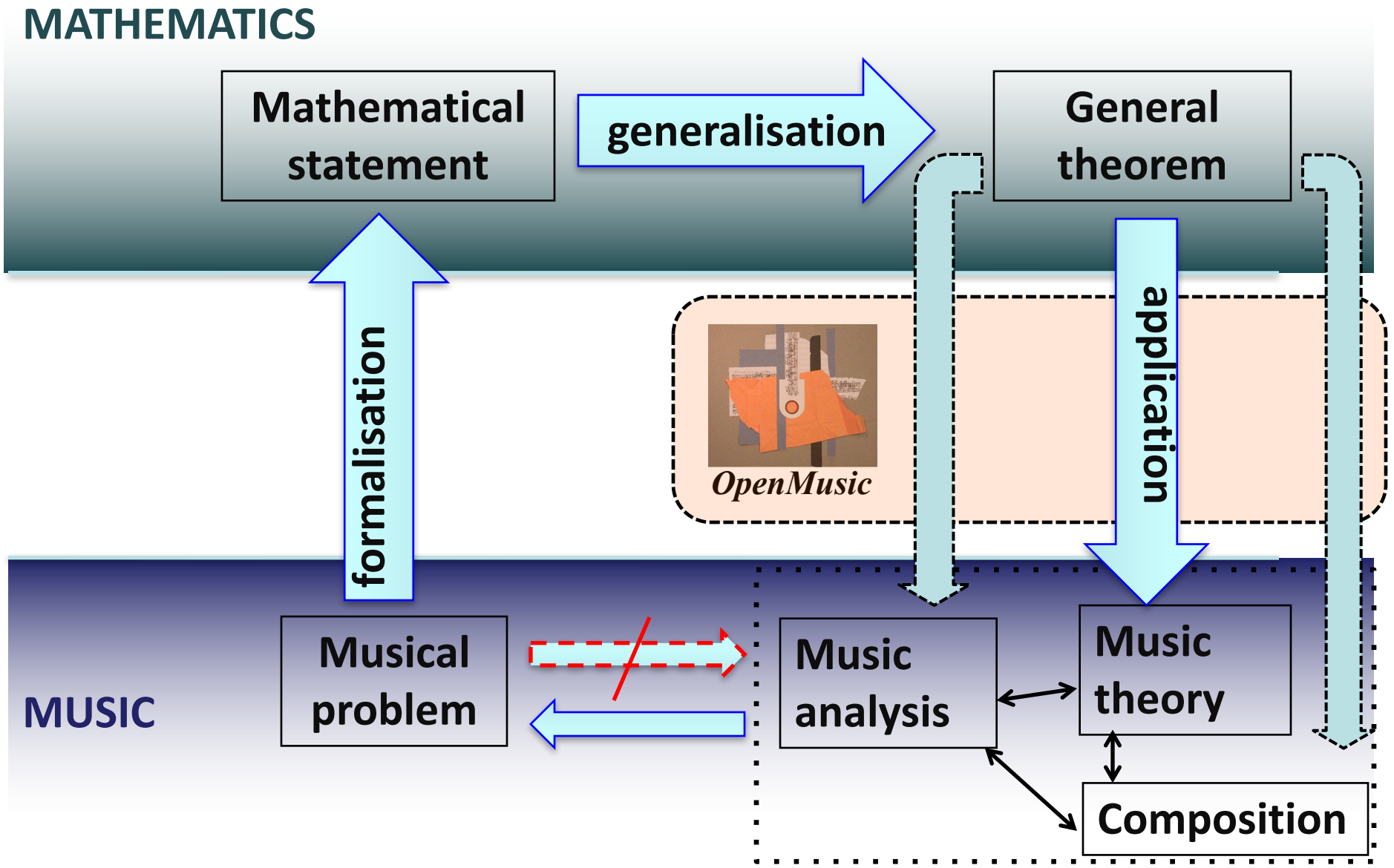
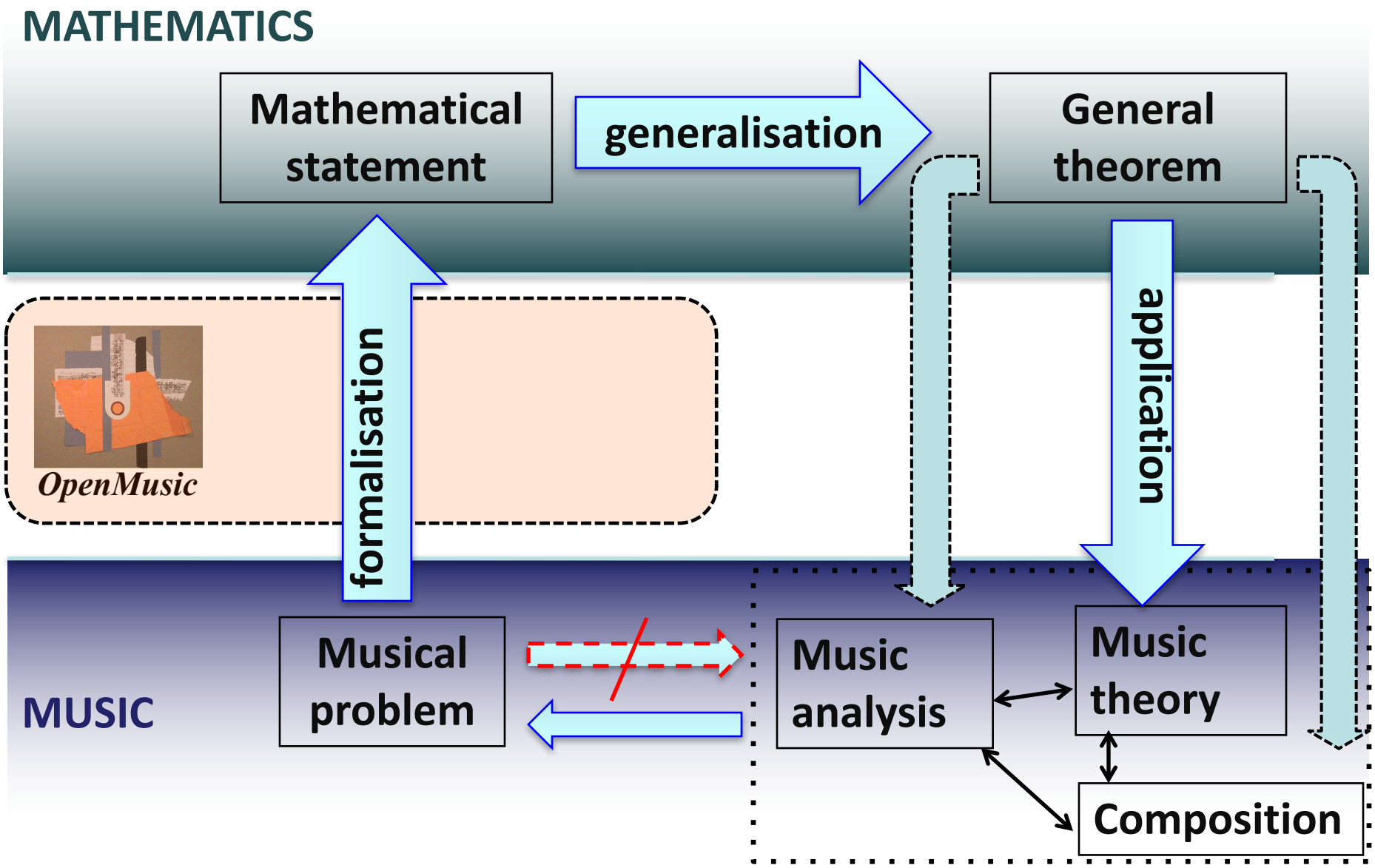
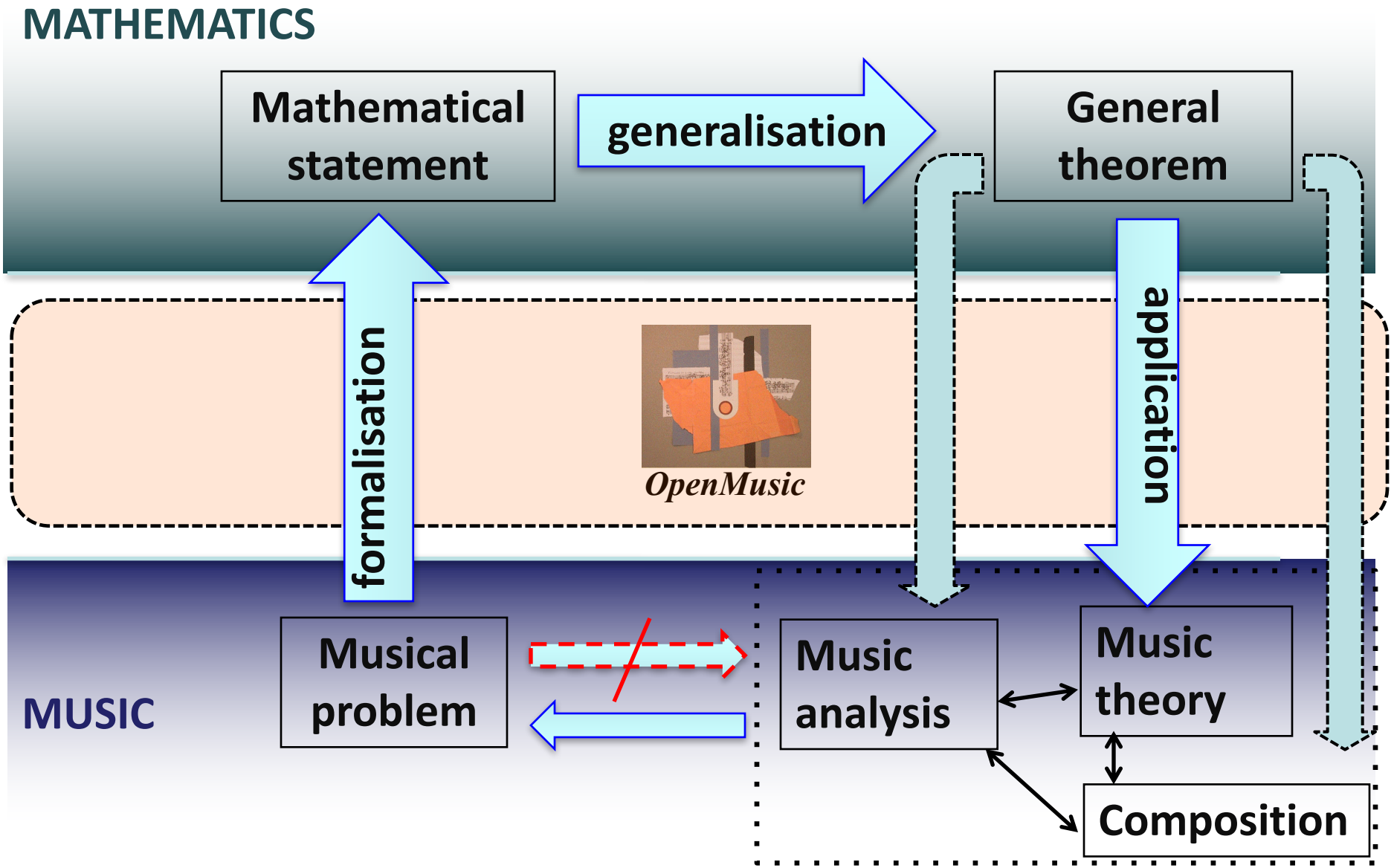
The double movement of a ‘mathemusical’ activity



The double movement of a ‘mathemusical’ activity



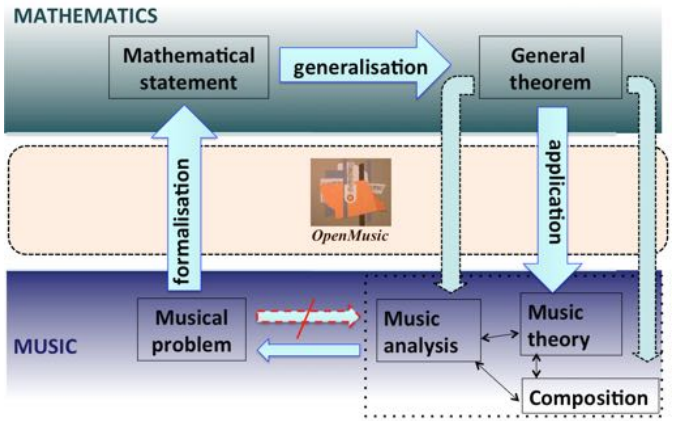
The double movement of a ‘mathemusical’ activity



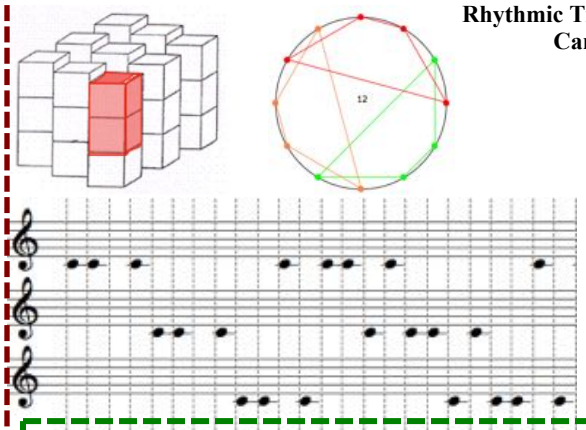
Some examples of ‘mathemusical’ problems

M. Andreatta : *Mathematica est exercitium musicae*, Habilitation Thesis, IRMA University of Strasbourg, 2010

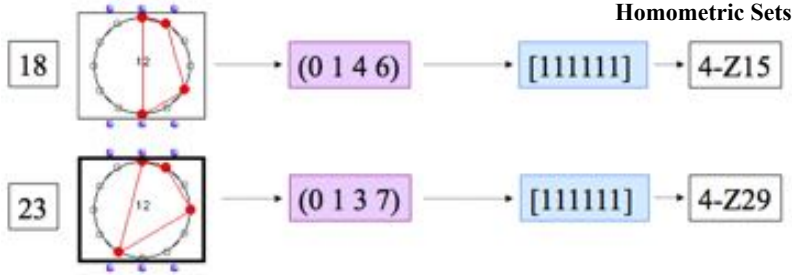
- The construction of Tiling Rhythmic Canons
- The *Z* relation and the theory of homometric sets
- *Set Theory* and Transformational Theory
- Neo-Riemannian Theory, Spatial Computing and FCA
- Diatonic Theory and Maximally-Even Sets
- Periodic sequences and finite difference calculus
- Block-designs and algorithmic composition

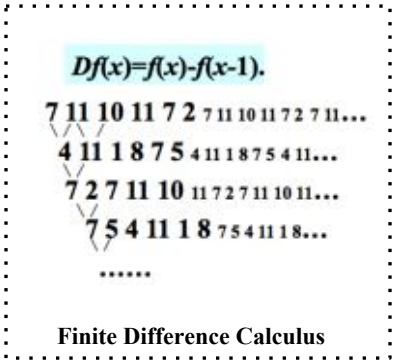


Rhythmic Tiling Canons



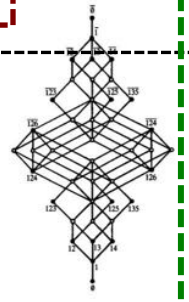
Z-Relation and Homometric Sets

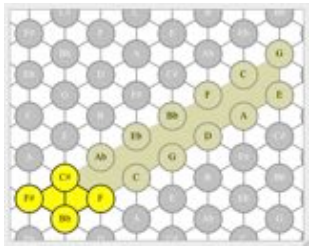


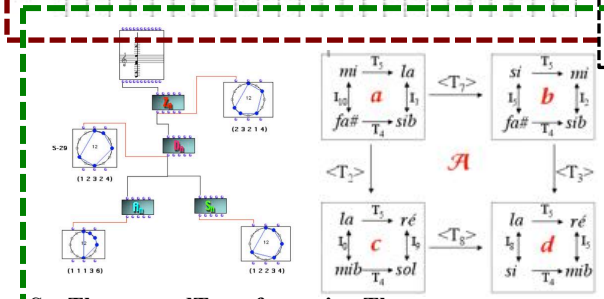


Finite Difference Calculus

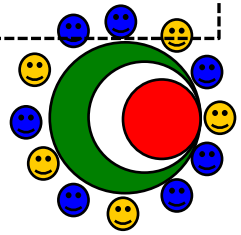
Neo-Riemannian Theory and Spatial Computing



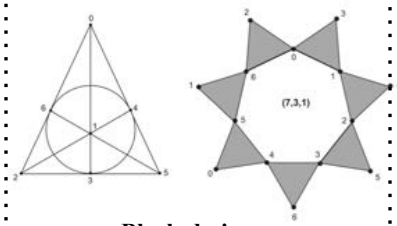




Set Theory, andTransformation Theory

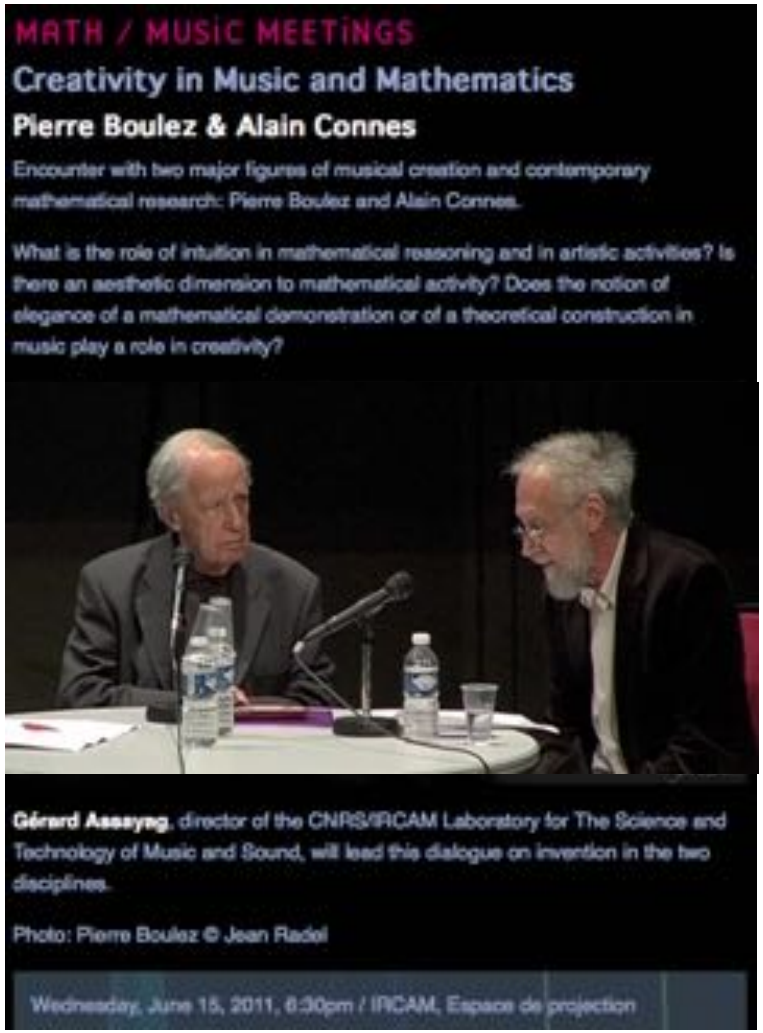


Diatonic Theory and ME-Sets



Block-designs

The interplay between algebra and geometry in music



"Concerning **music**, it takes place in **time**, like **algebra**. In **mathematics**, there is this fundamental duality between, on the one hand, **geometry** – which corresponds to the visual arts, an immediate intuition – and on the other hand **algebra**. This is not visual, it has a temporality. This fits in time, it is a computation, something that is very close to the language, and which has its diabolical precision. [...] **And one only perceives the development of algebra through music**" (A. Connes).

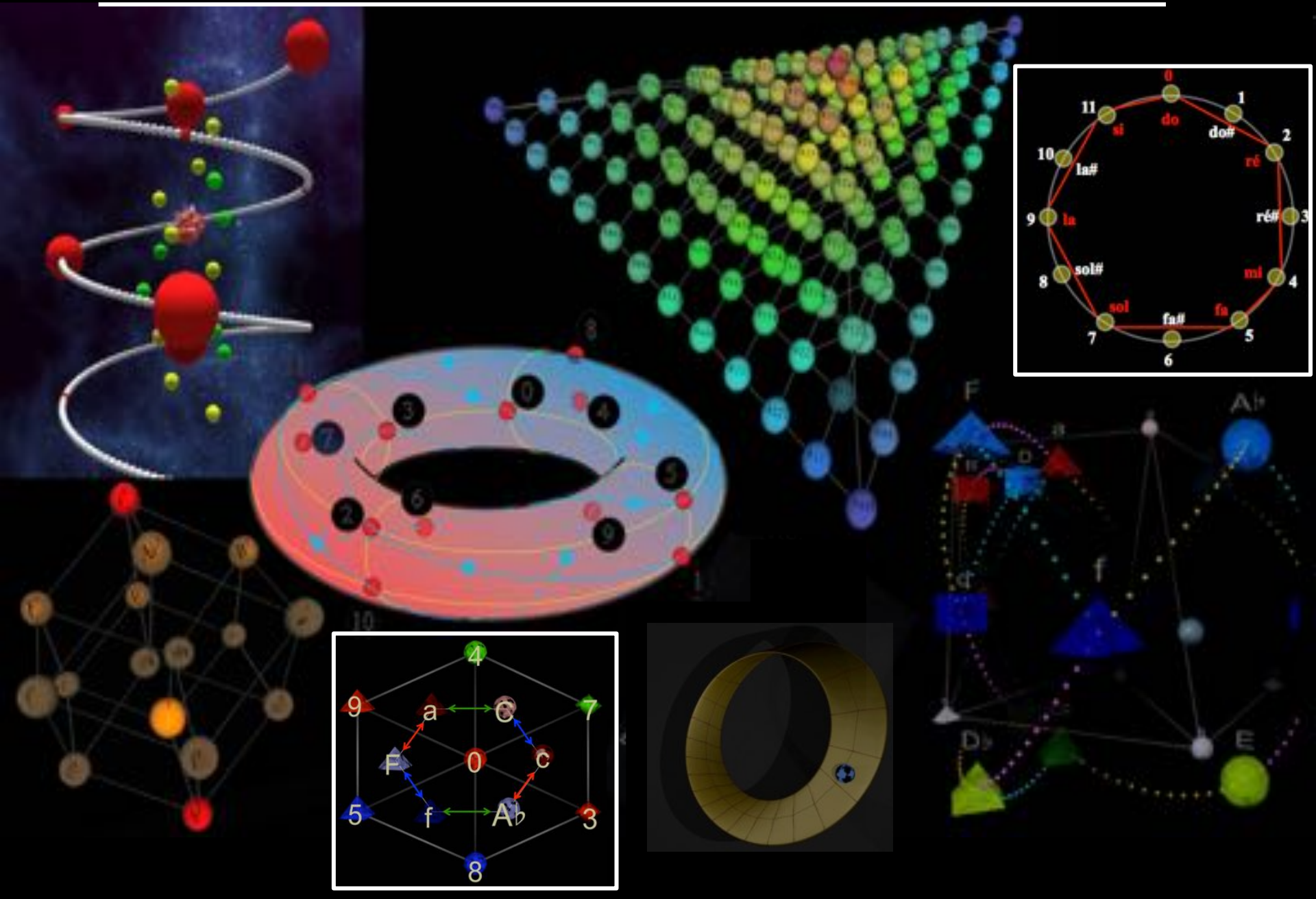
➔ `http://videotheque.cnrs.fr/`

➔ `http://agora2011.ircam.fr`

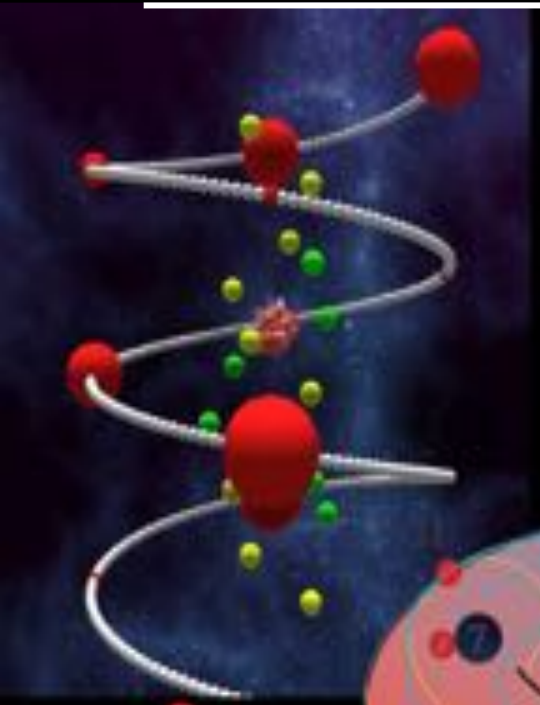
ircam Centre Pompidou AGORA FESTIVAL 8-18 JUIN 2011

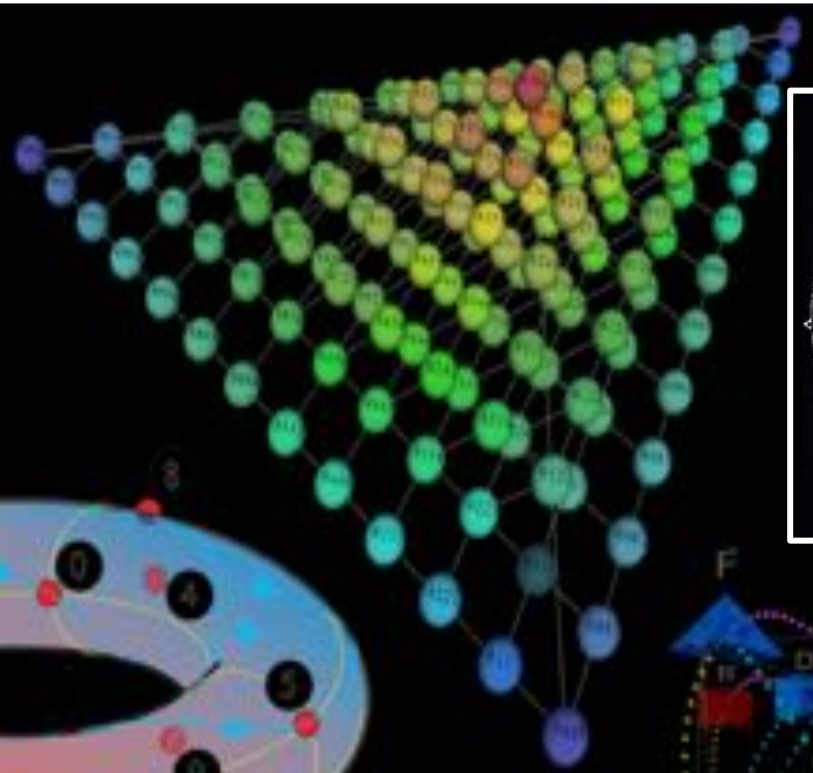
Société Mathématique de France SMF

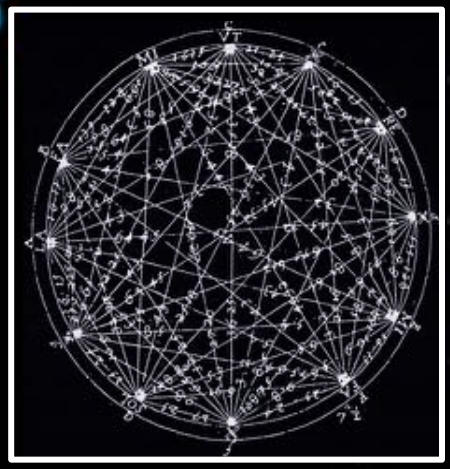
The galaxy of geometrical models at the service of music

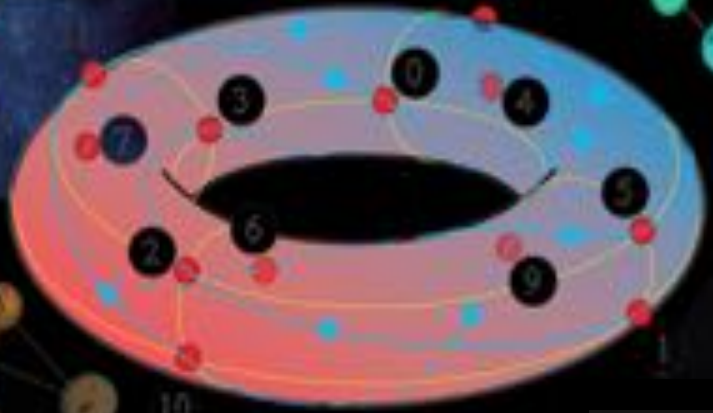


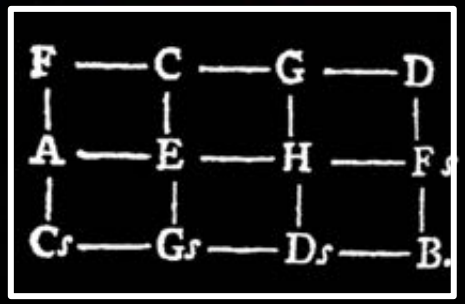
The galaxy of geometrical models at the service of music

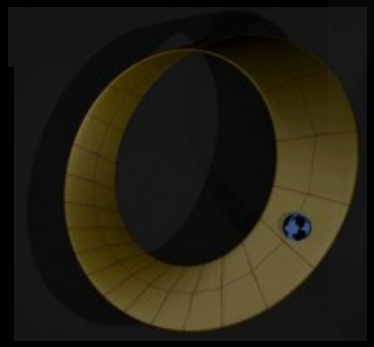






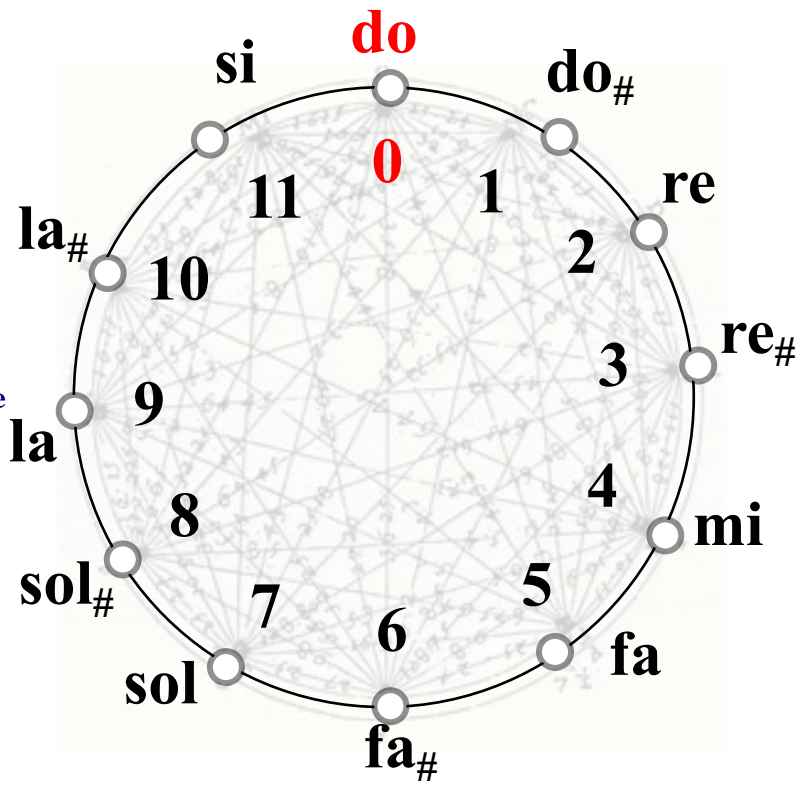




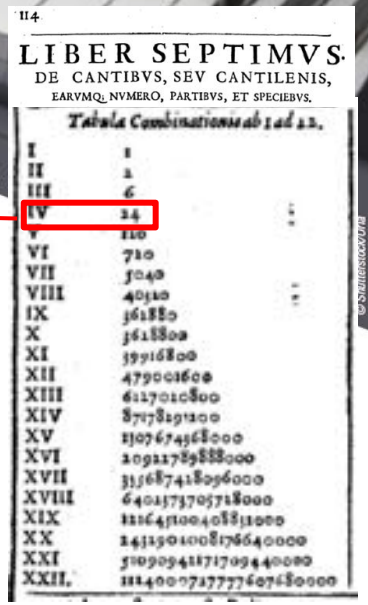


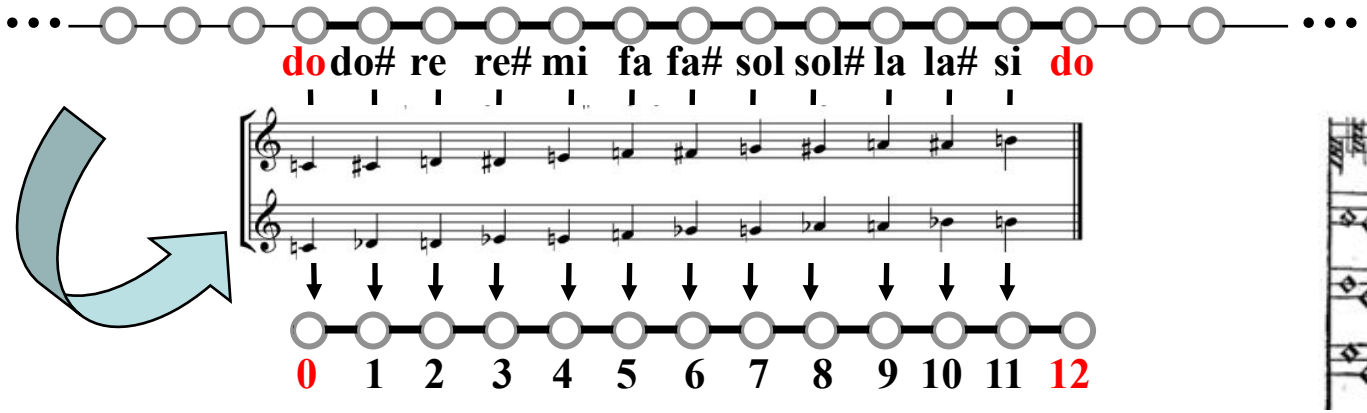
The circular representation of the pitch space

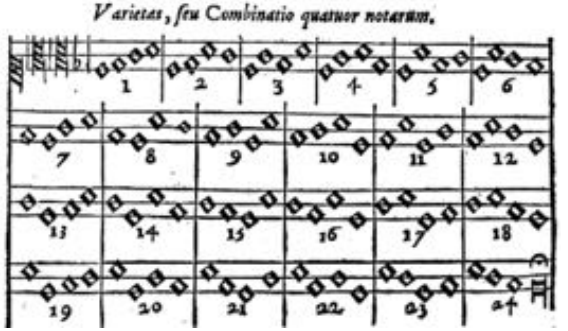
Marin Mersenne



Harmonicorum Libri XII, 1648







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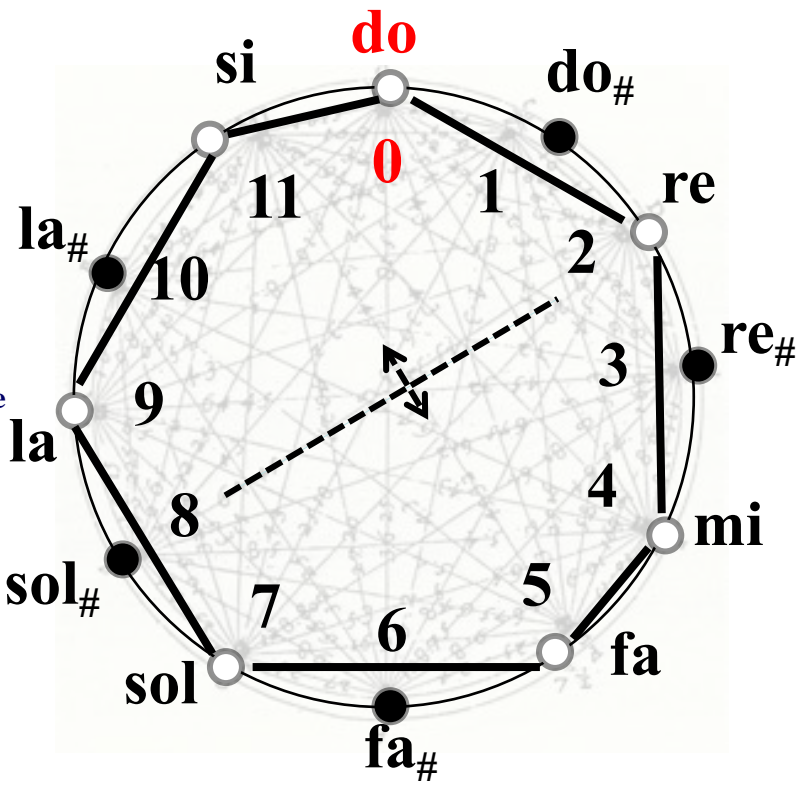

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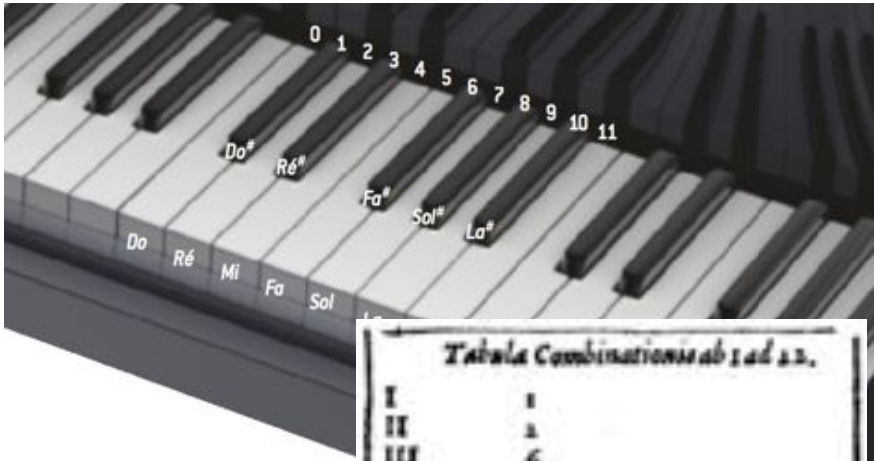
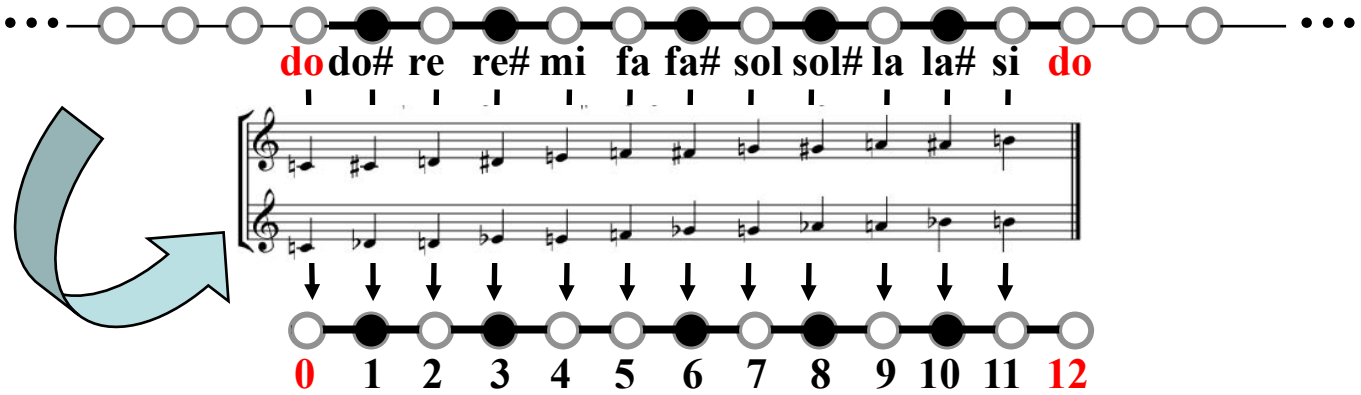


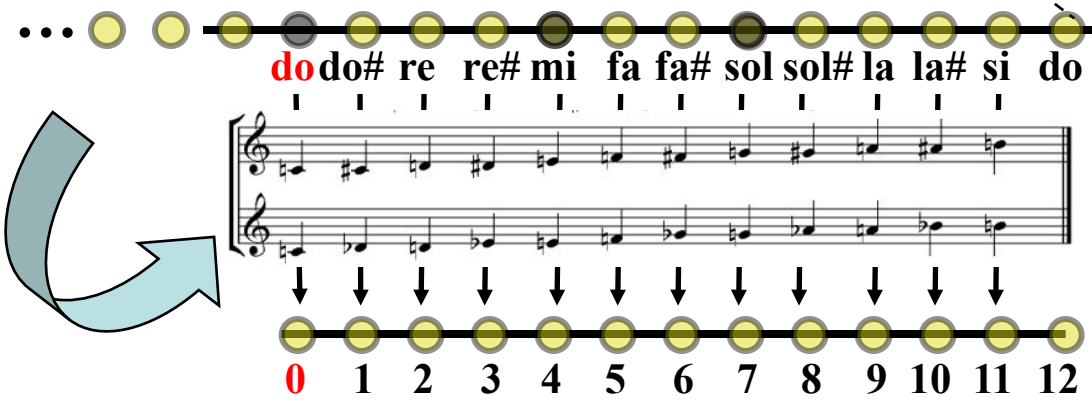


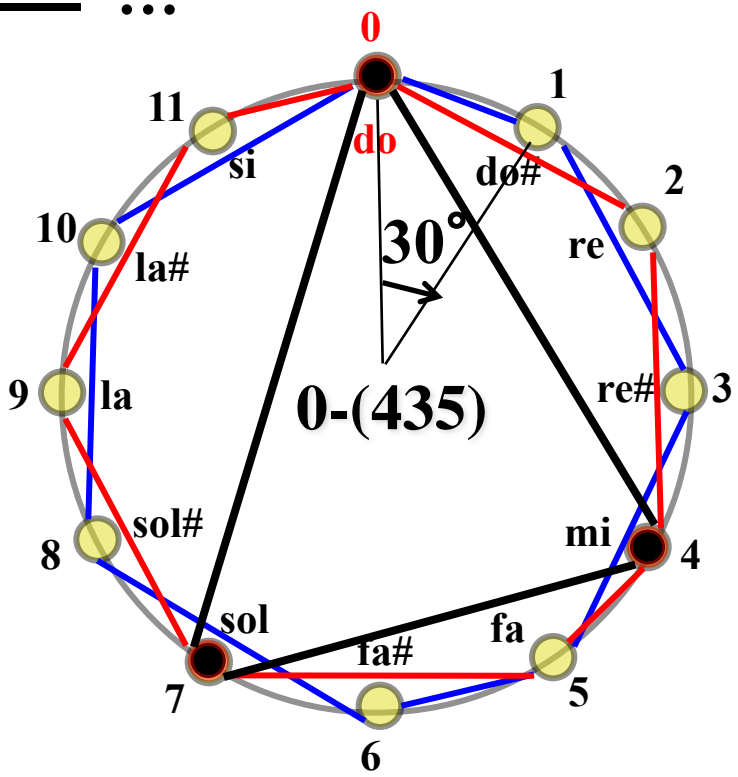
Musical transpositions are additions...

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

***Do* maj** = {0,2,4,5,7,9,11} +1

***Do#* maj** = {1,3,5,6,8,10,0}





...or rotations !

Musical transpositions are additions...

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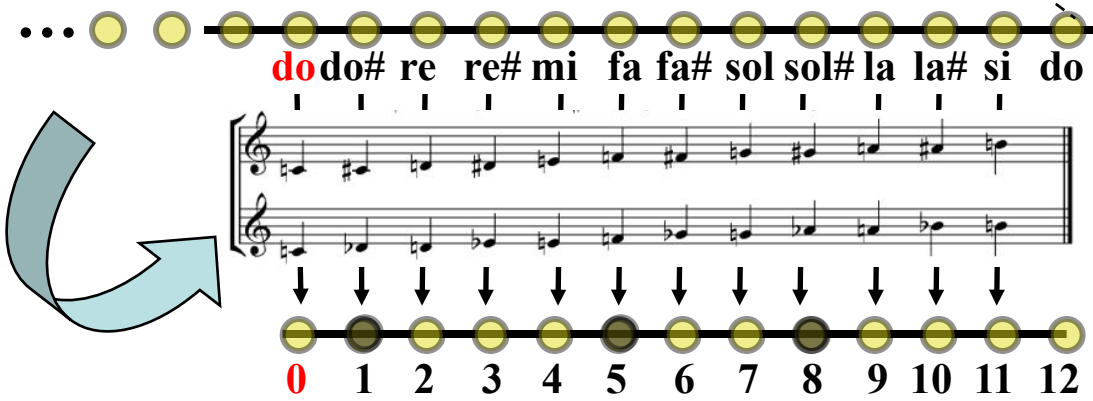
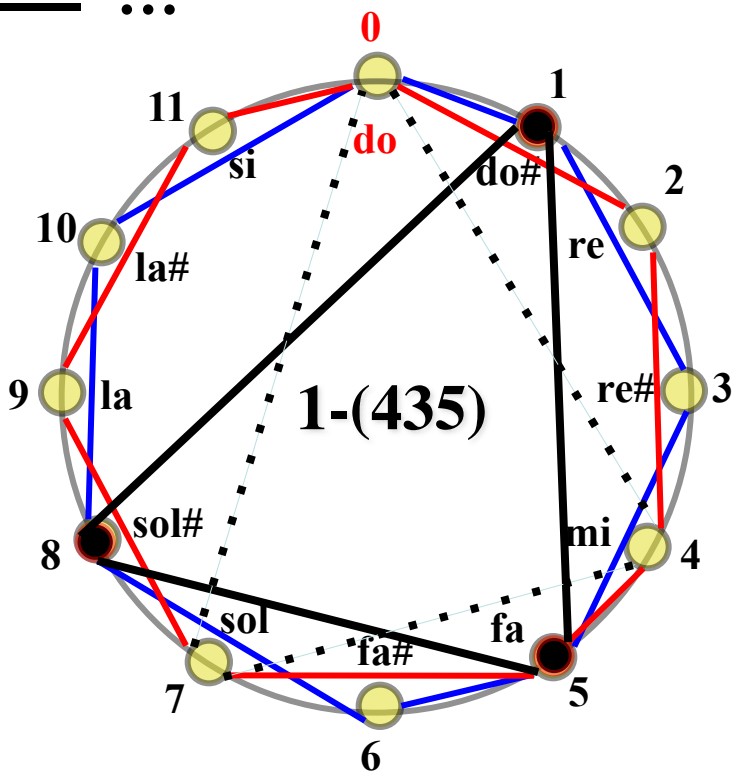




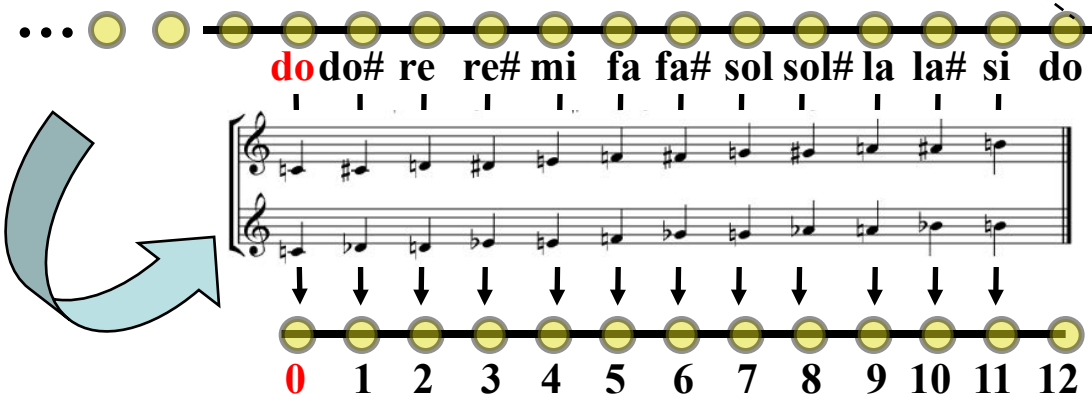
...or rotations !

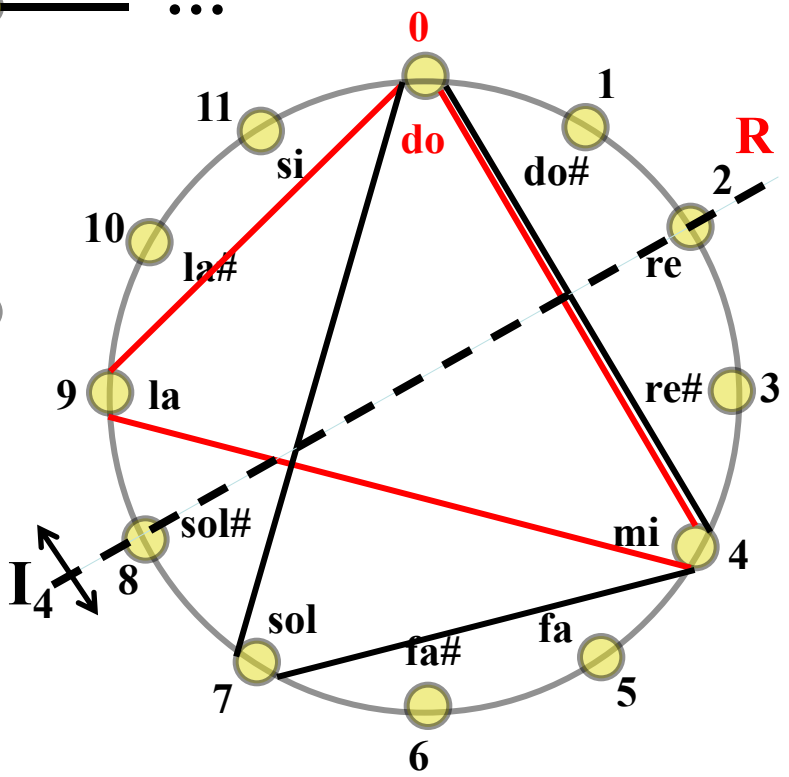
Musical inversions are differences...

I : $x \rightarrow -x$ mod 12

***Do* maj = {0,4,7}**
***La* min = {0,4,9}**

$I_4(x)=4-x$





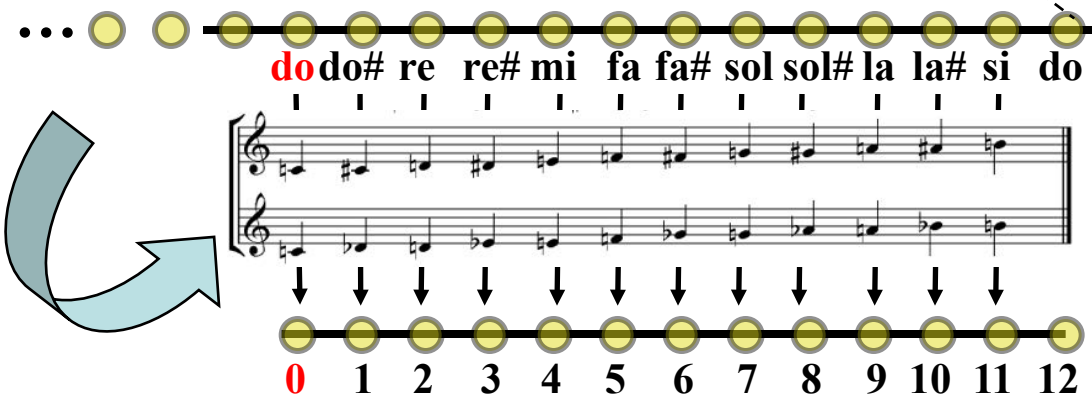
... or axial symmetries!

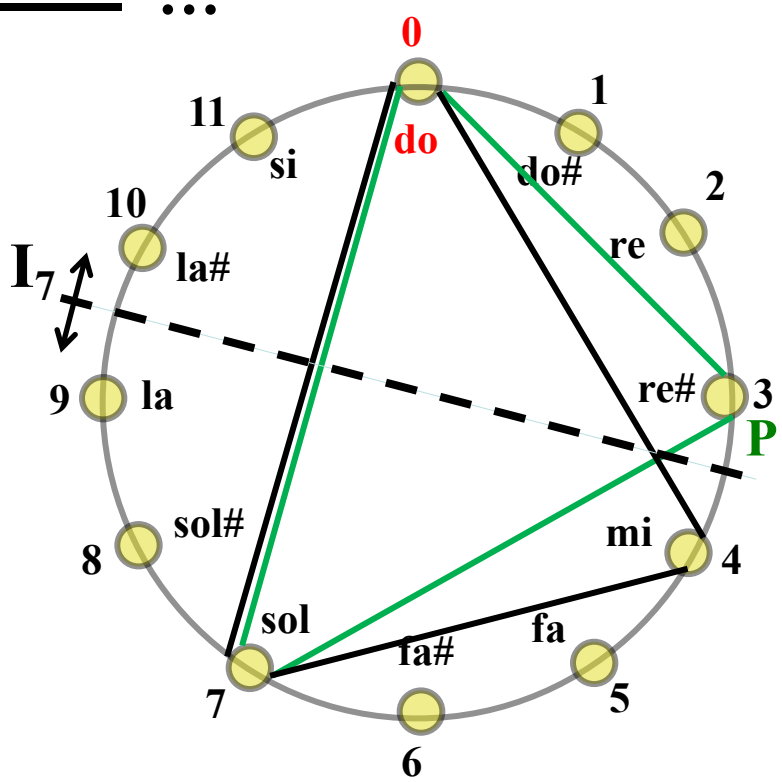
Musical inversions are differences...

I : $x \rightarrow -x$ mod 12

***Do* maj = {0,4,7}**
***Do* min = {0,3,7}**

$I_7(x)=7-x$





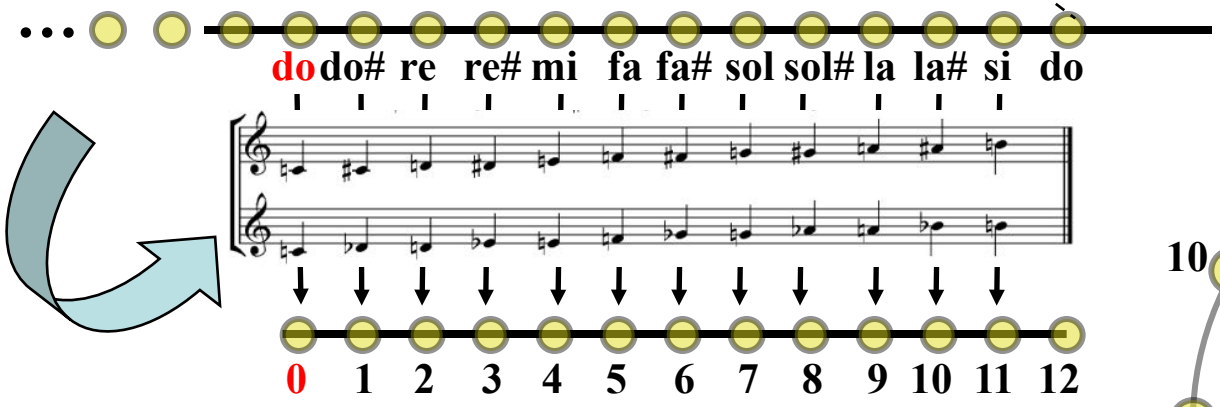
... or axial symmetries!

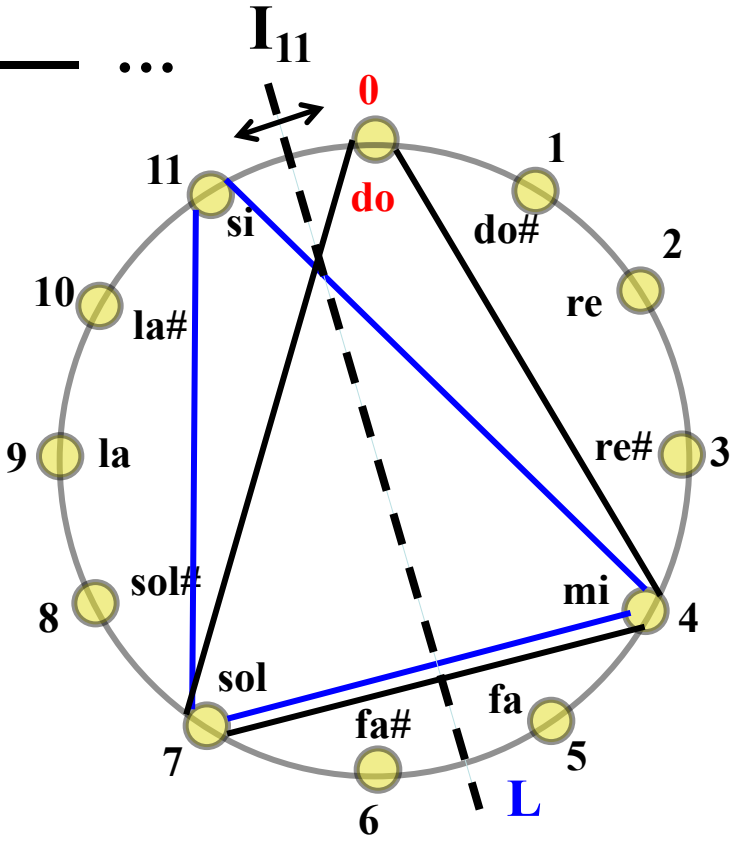
Musical inversions are differences...

I : $x \rightarrow -x$ mod 12

***Do* maj = {0,4,7}**
***Mi* min = {4,7,11}**

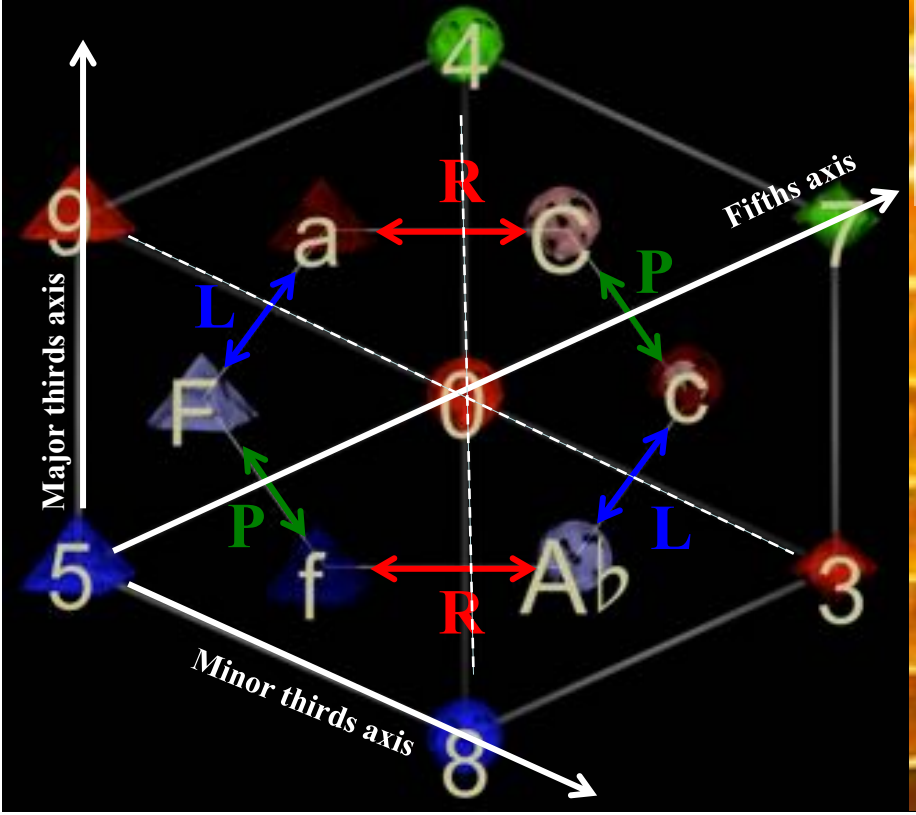
$I_{11}(x)=11-x$

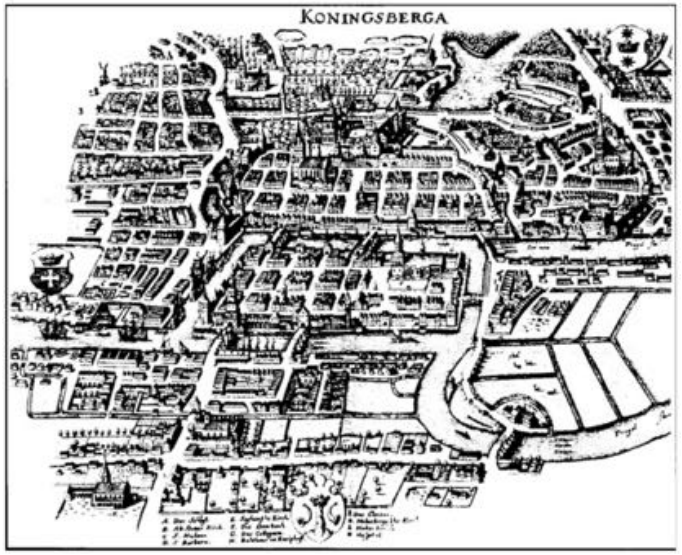


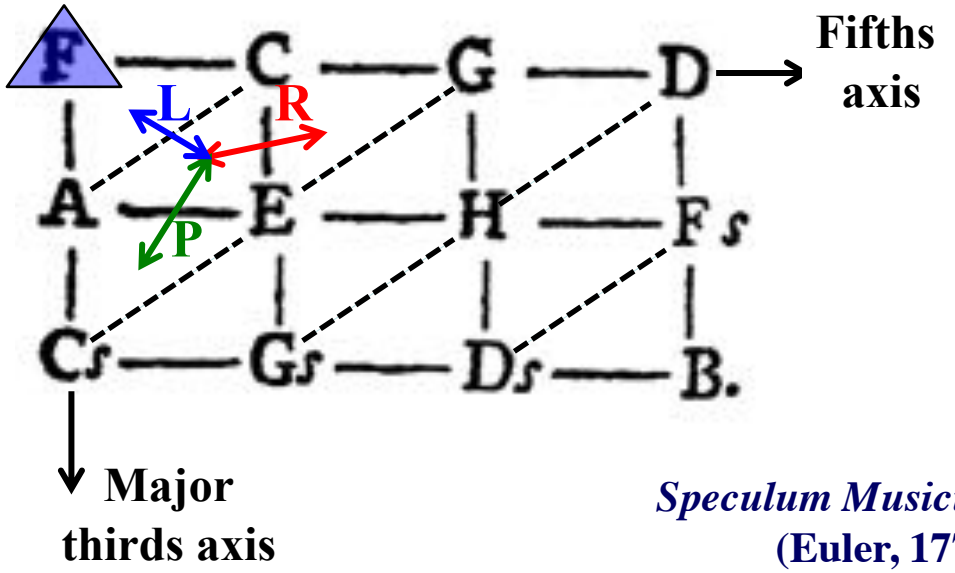


... or axial symmetries!

The *Tonnetz*
(or 'honeycomb' hexagonal tiling)

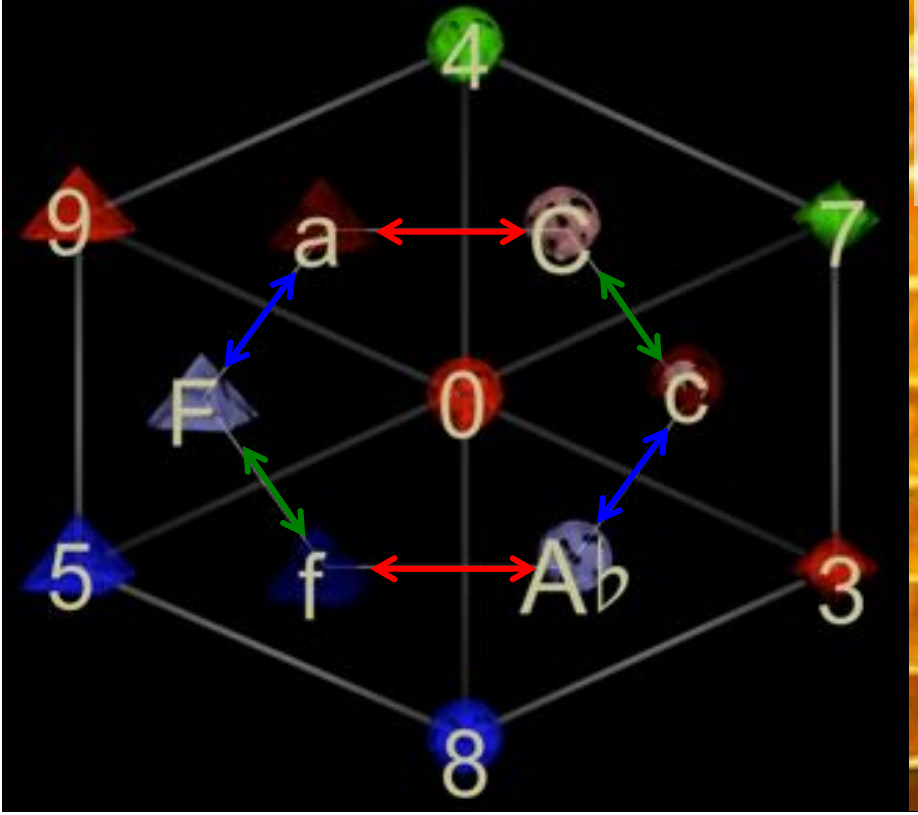


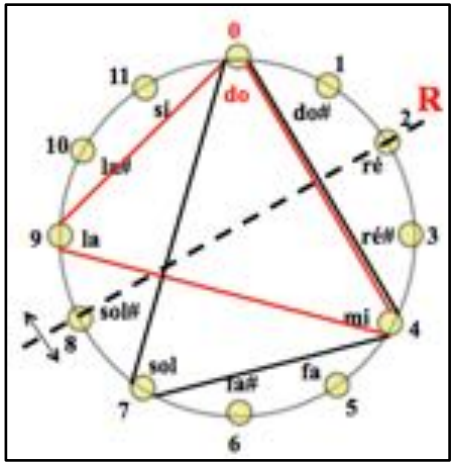


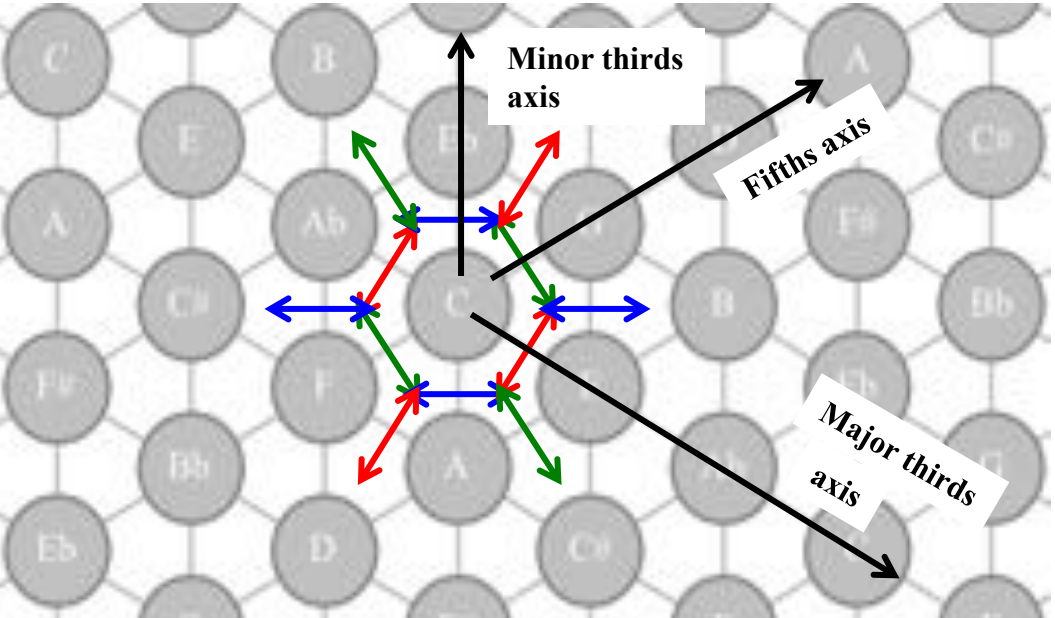


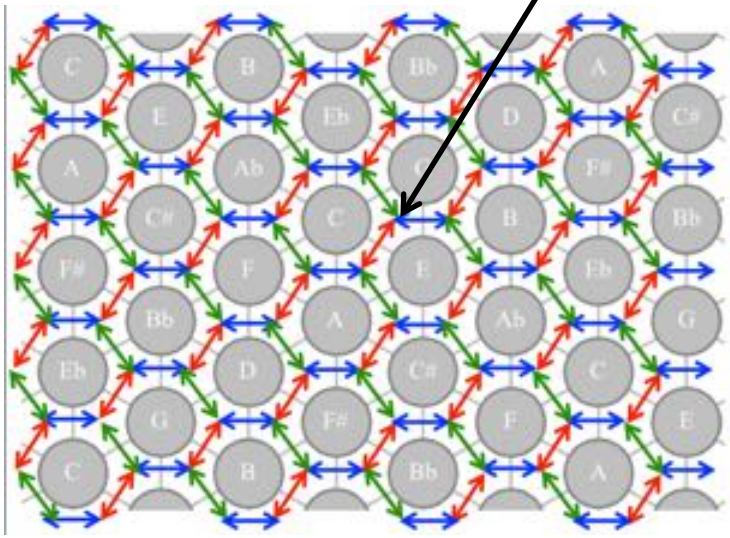
Speculum Musicum
(Euler, 1773)

The *Tonnetz*
(or 'honeycomb' hexagonal tiling)

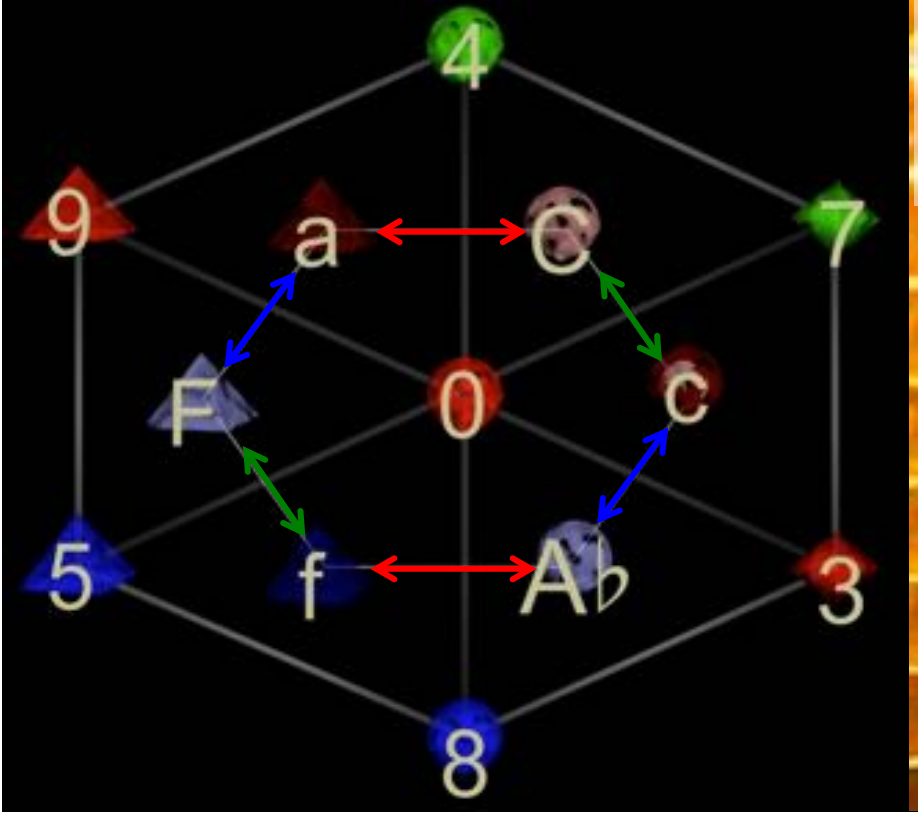


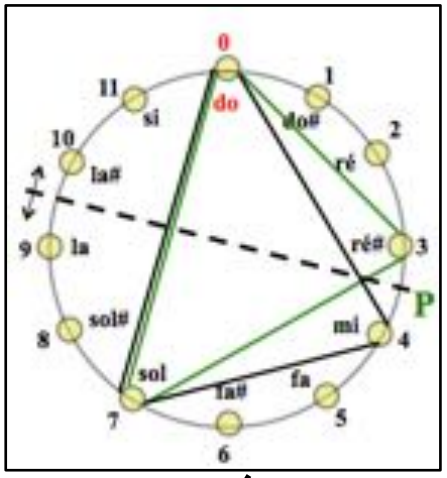


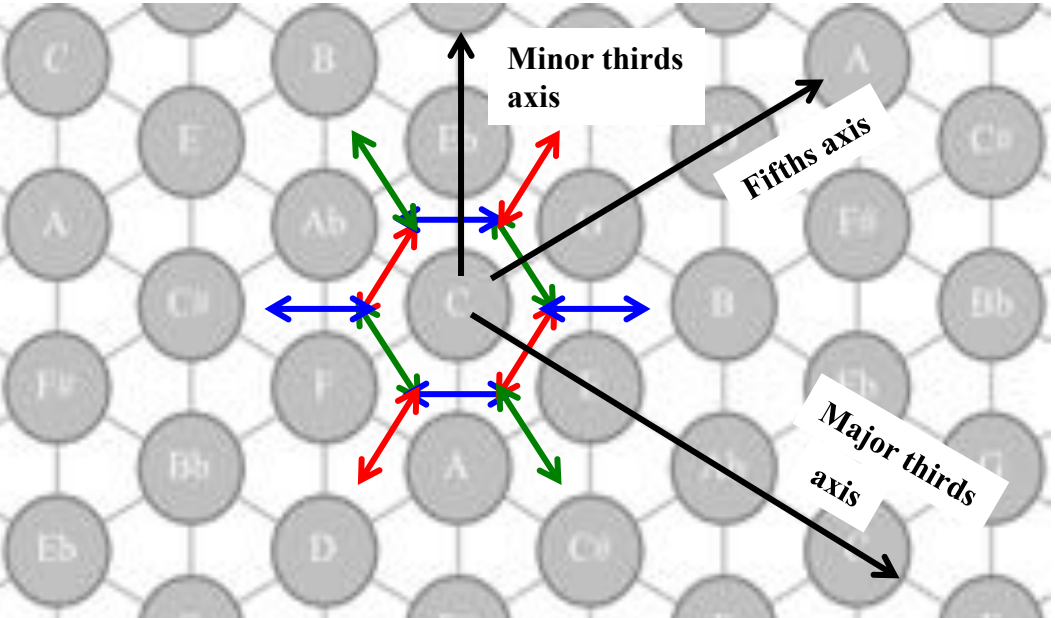


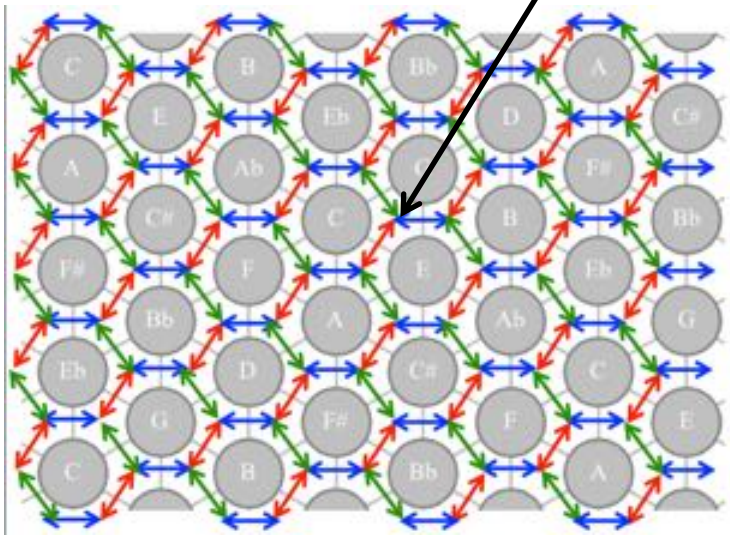


The *Tonnetz*
(or 'honeycomb' hexagonal tiling)

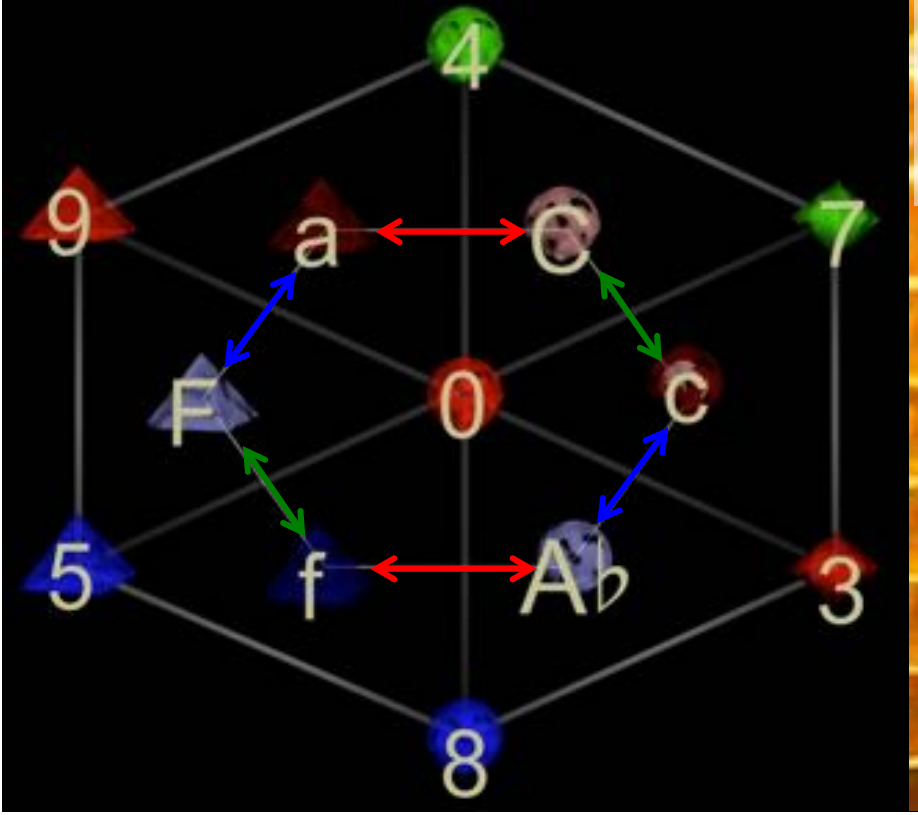


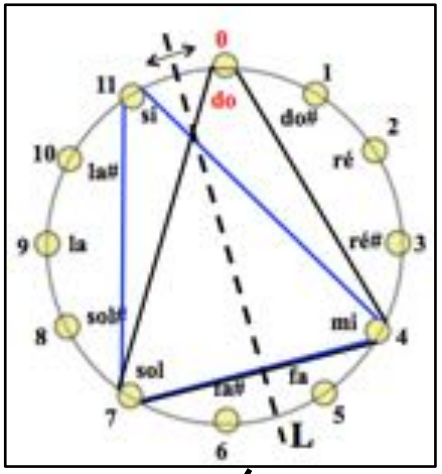


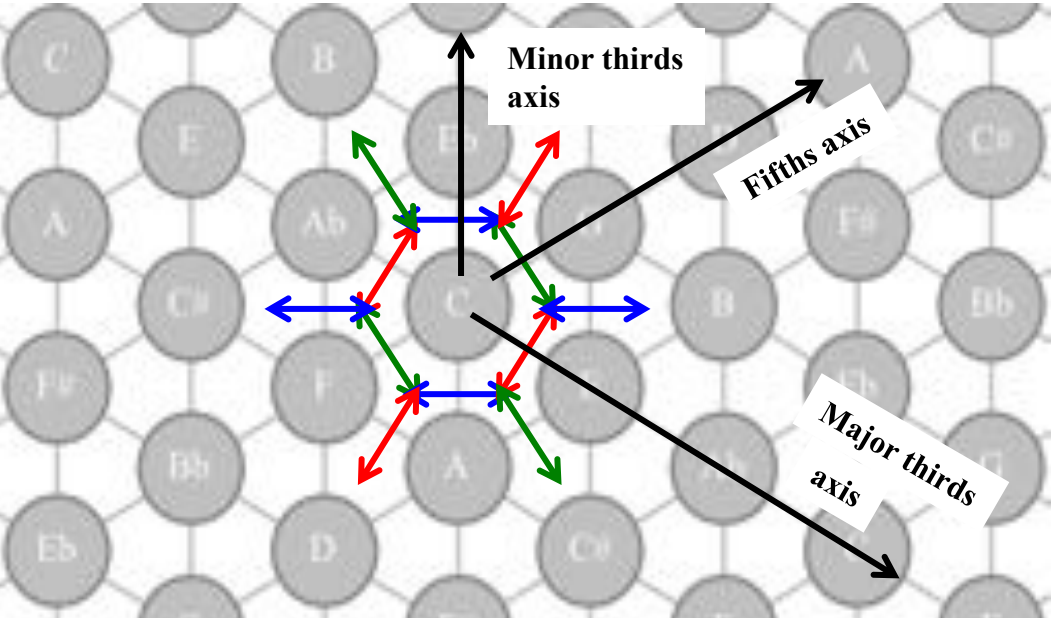


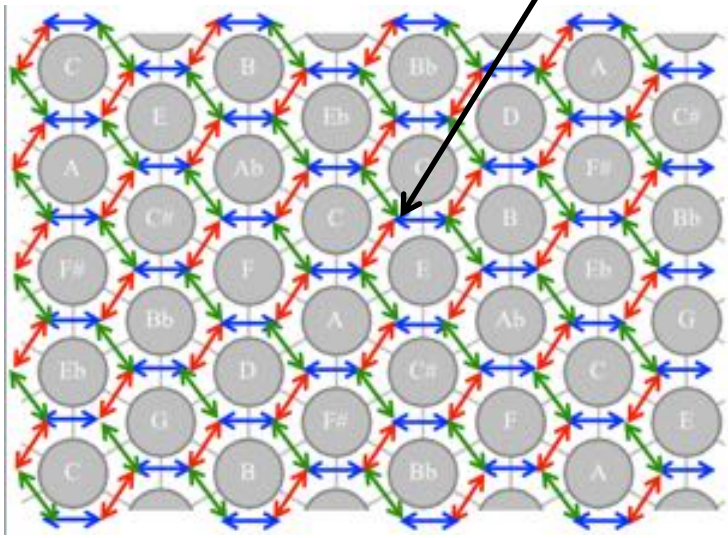


The *Tonnetz*
(or 'honeycomb' hexagonal tiling)



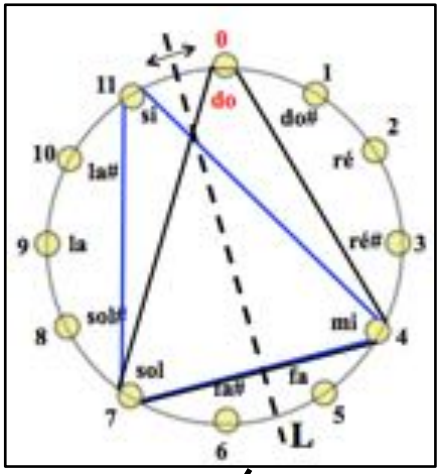


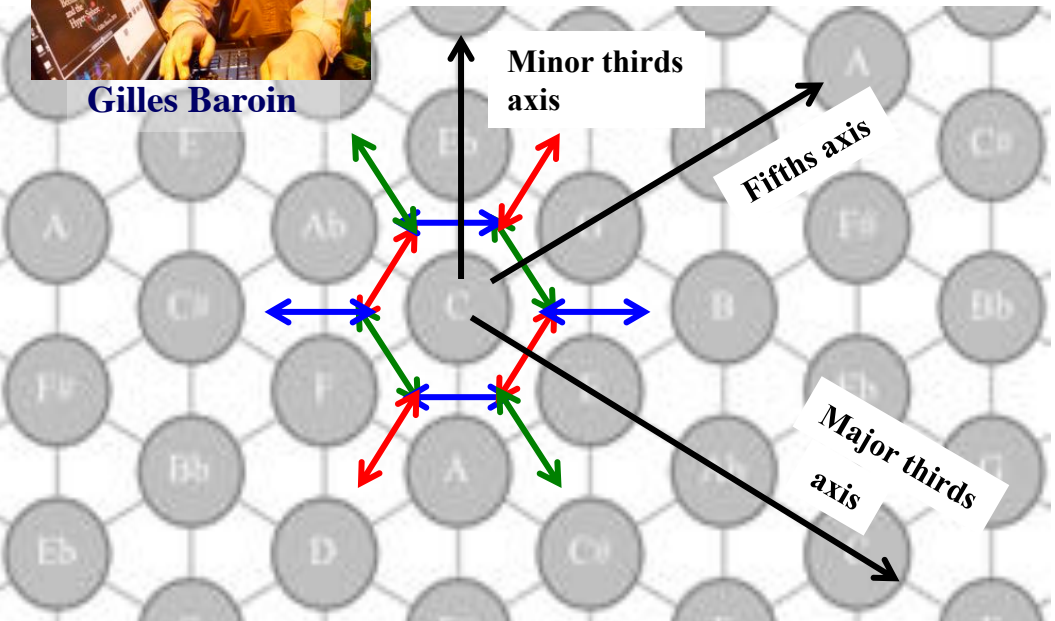


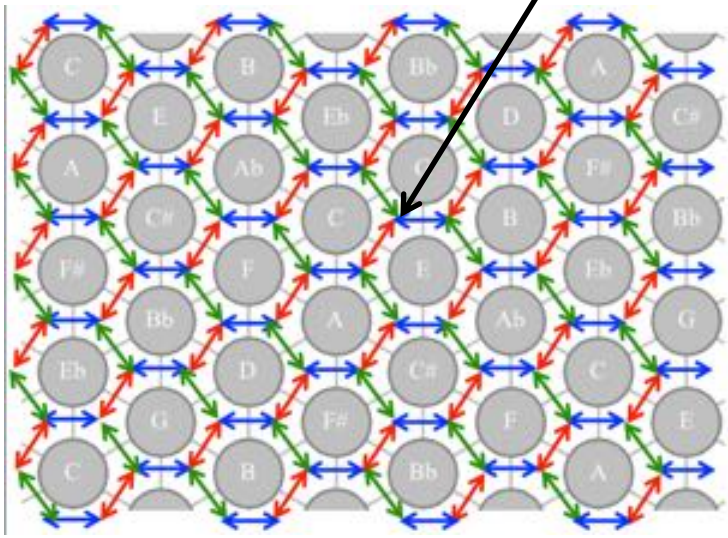


The *Tonnetz*
(or 'honeycomb' hexagonal tiling)

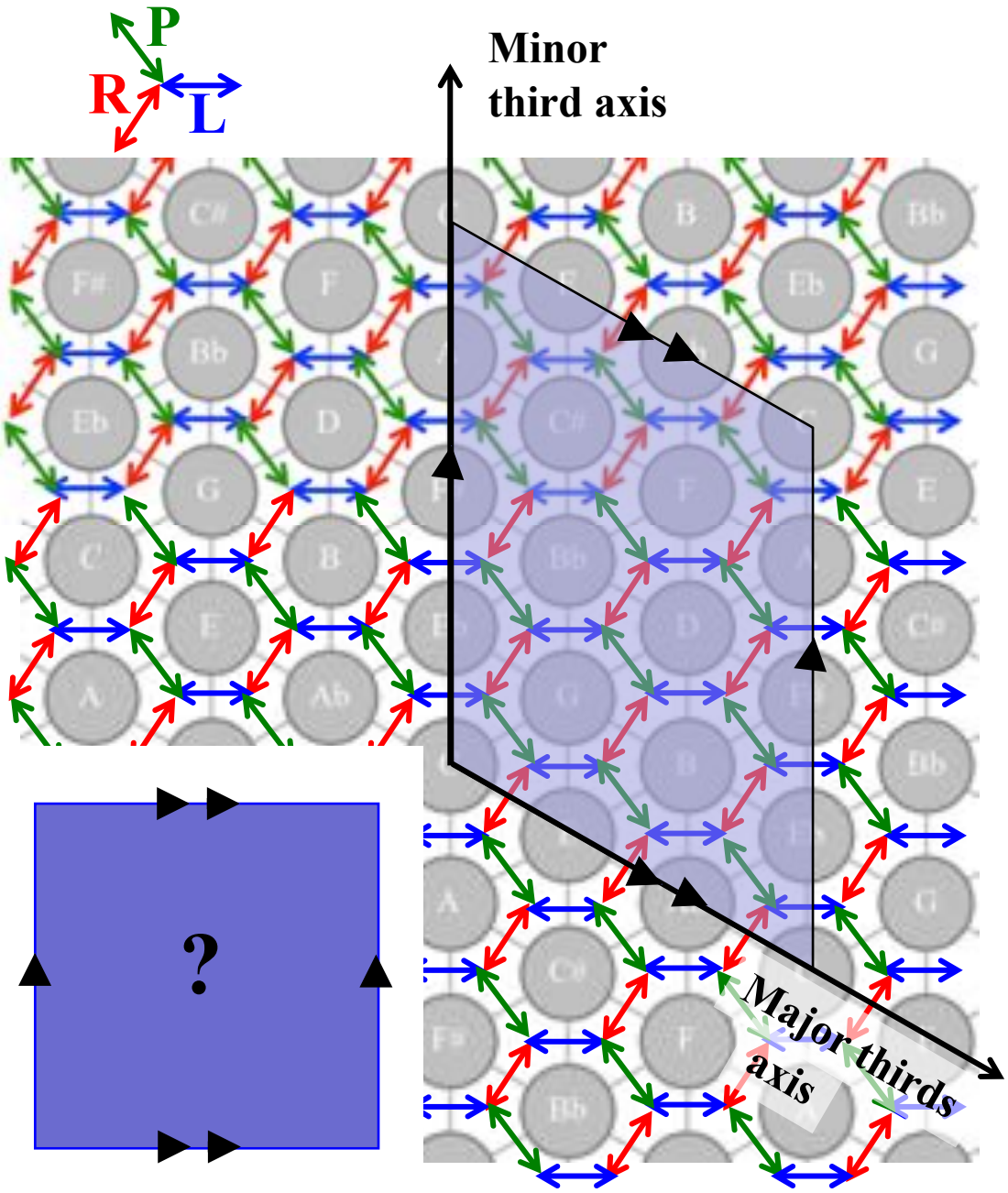
Gilles Baroin

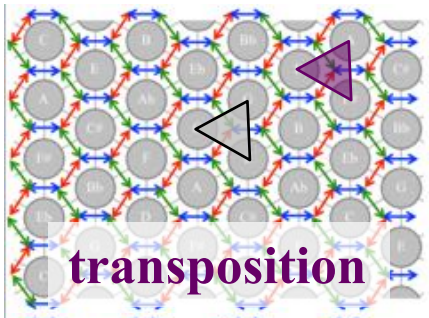


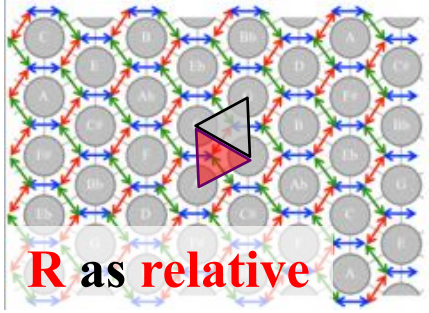


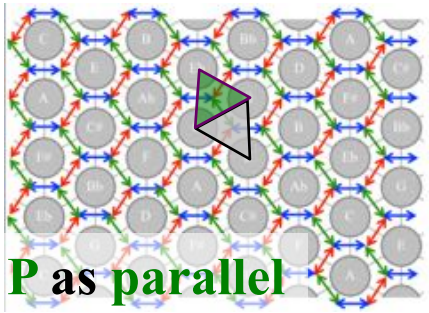


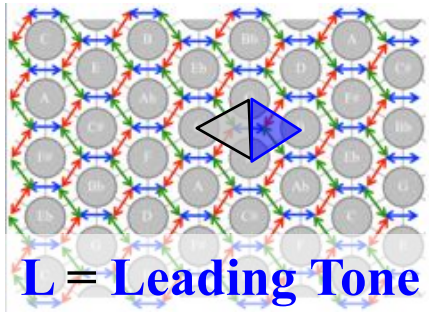
The *Tonnetz*, its symmetries and its topological structure

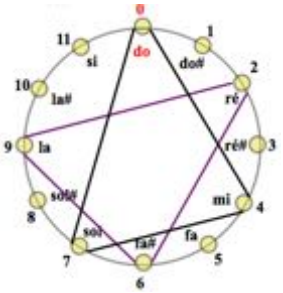


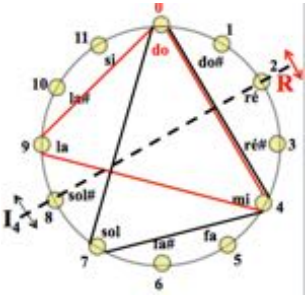


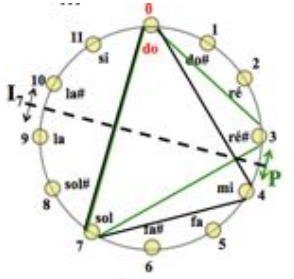


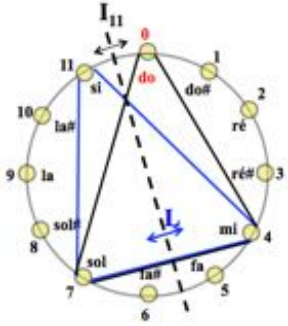




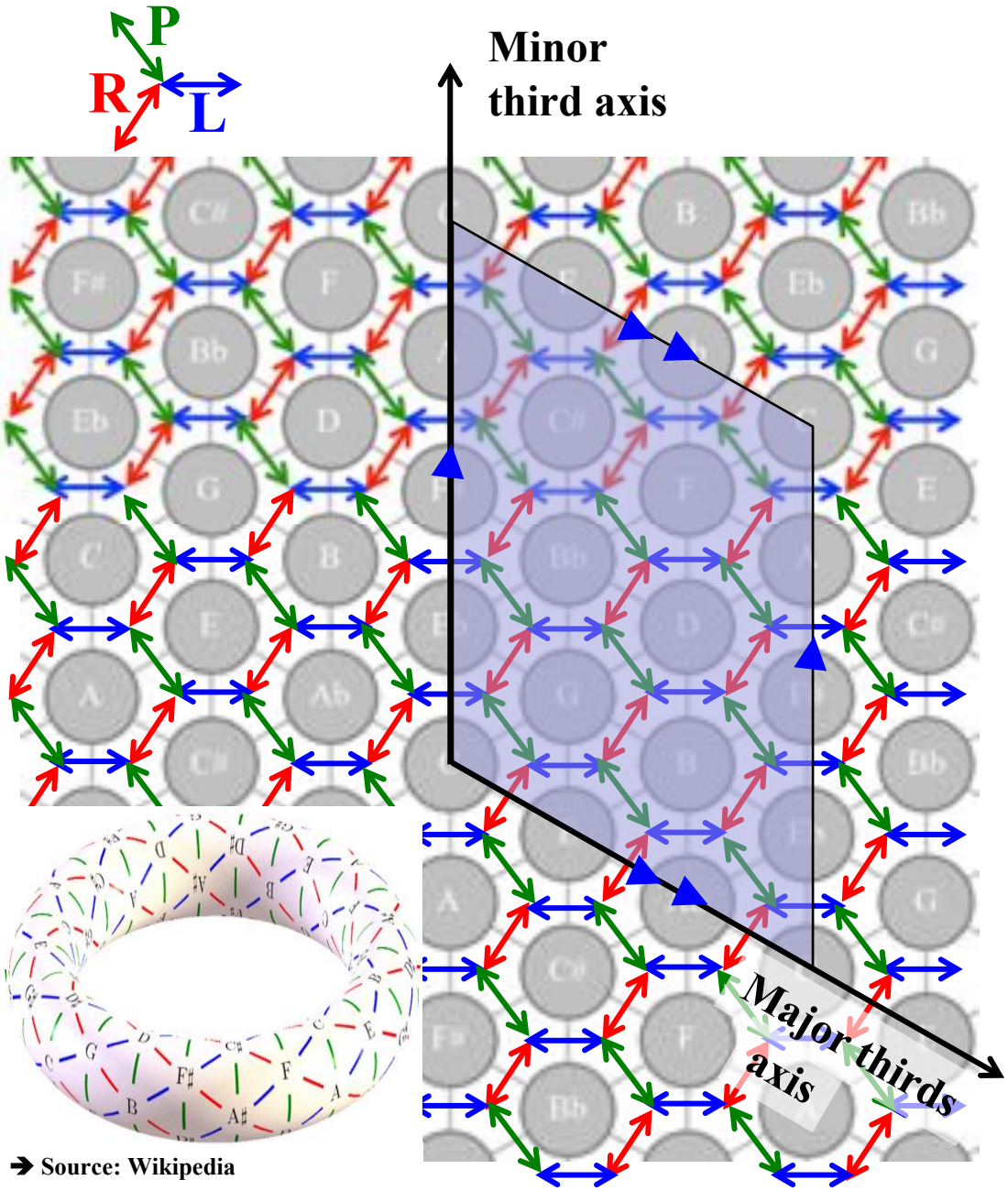




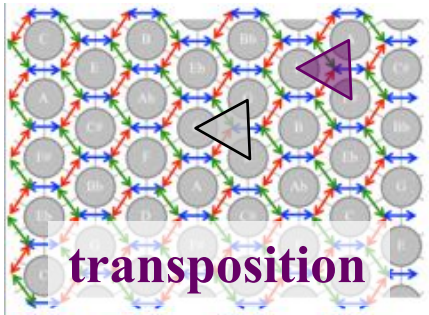


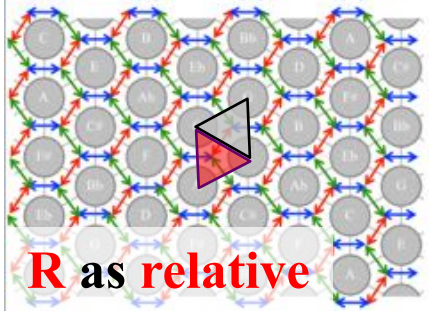


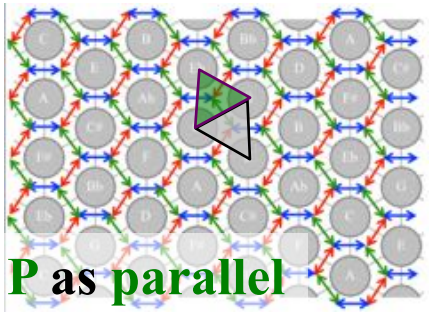
The *Tonnetz*, its symmetries and its topological structure

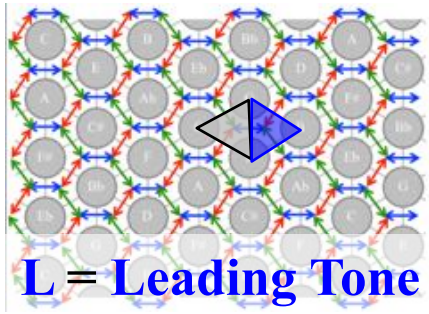


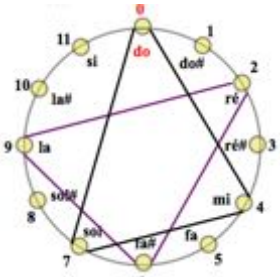
➔ Source: Wikipedia

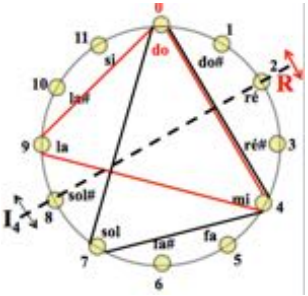


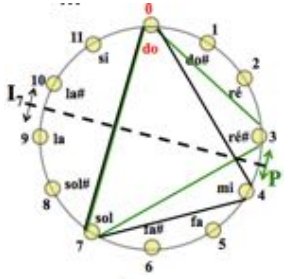


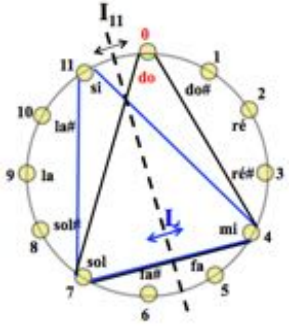




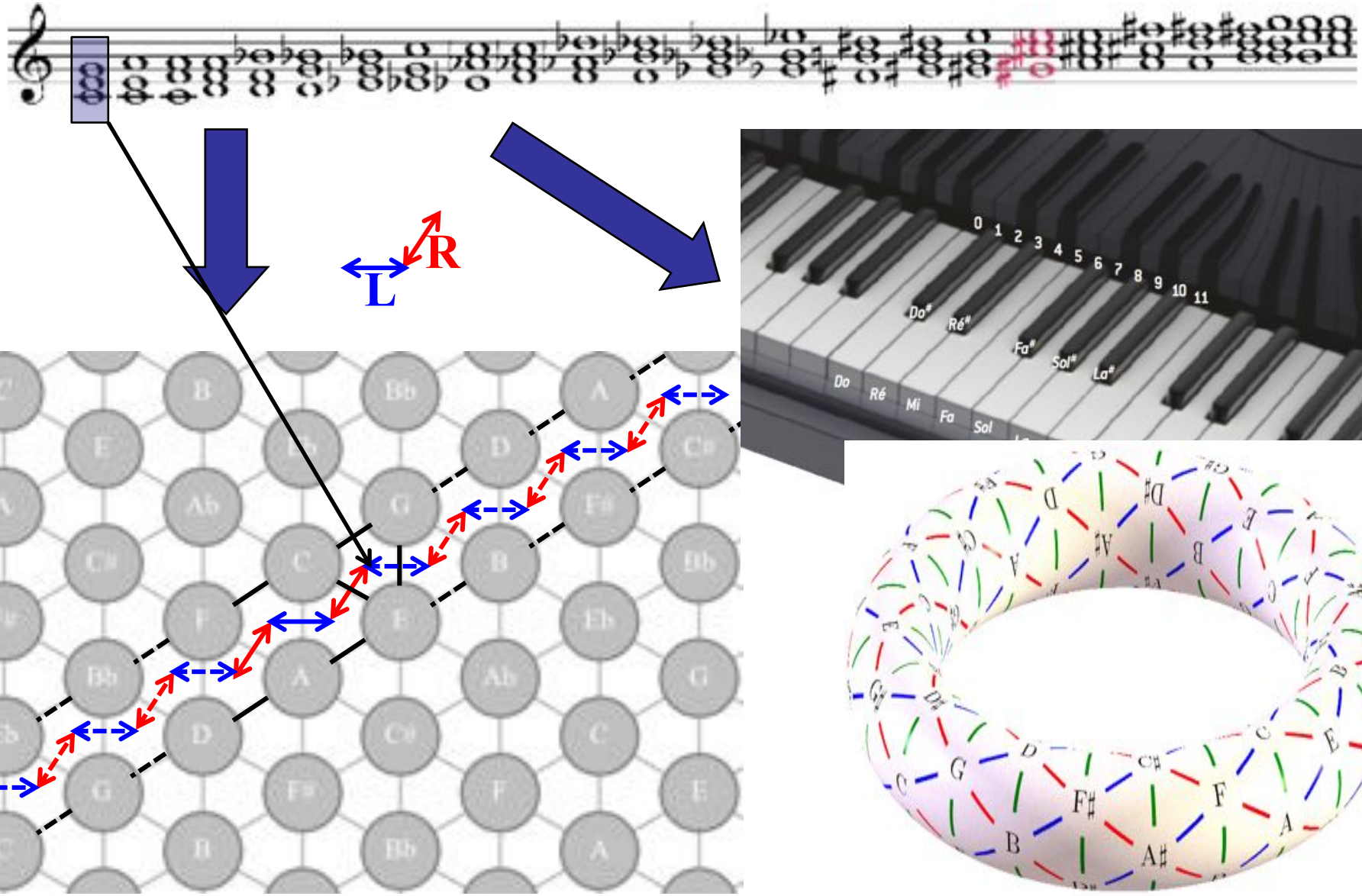








Harmonic progressions as spatial trajectories



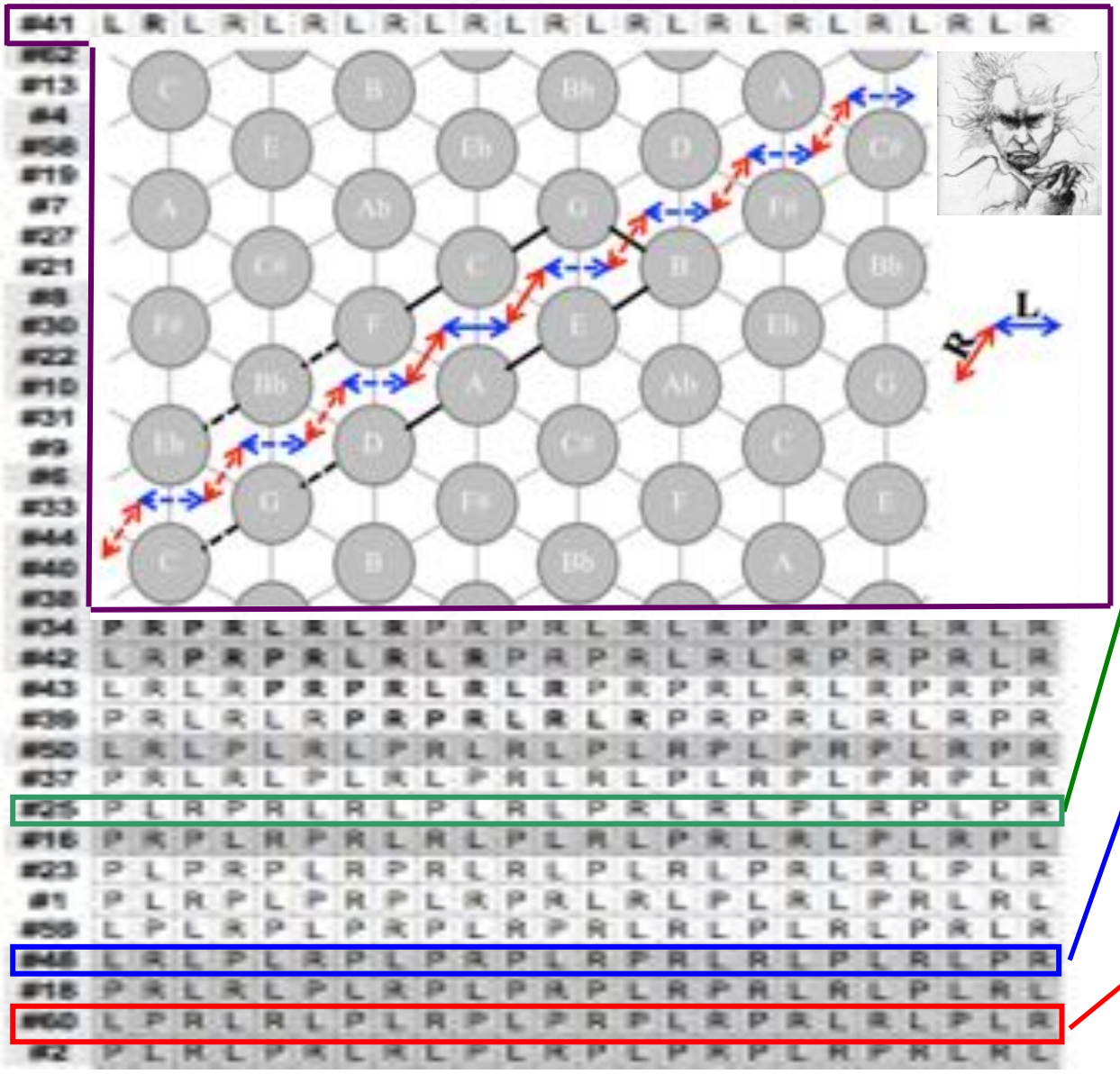
➔ Source : https://upload.wikimedia.org/wikipedia/commons/6/67/TonnetzTorus.gif

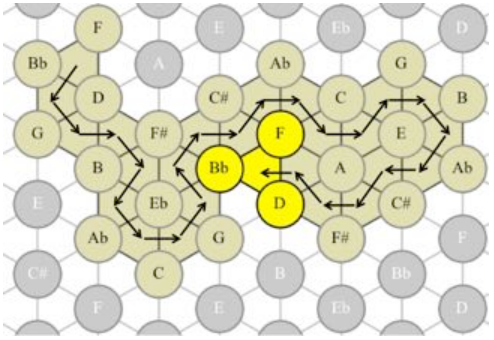
Beethoven and the Hypersphere

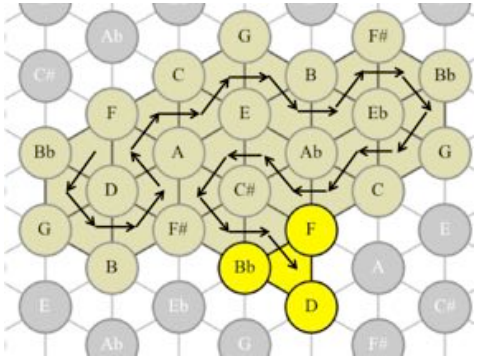
(and the Tonnetz)

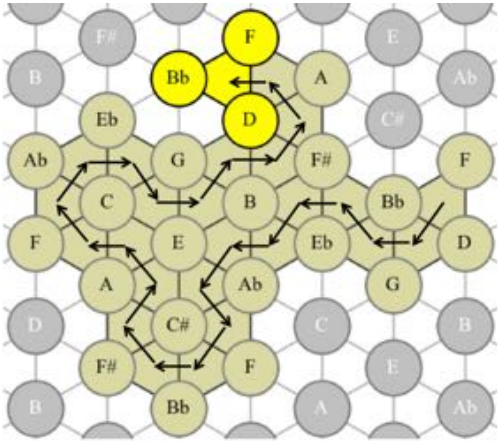
Gilles Baroin 2016
www.MatheMusic.net

Hamiltonian cycles and song writing









G. Albini et S. Antonini, « Hamiltonian Cycles in the Topological Dual of the Tonnetz », MCM 2009, LNCS Springer

Aprile, a Hamiltonian « decadent » song

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

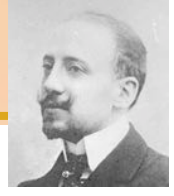
↘ La ↗ ↗

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

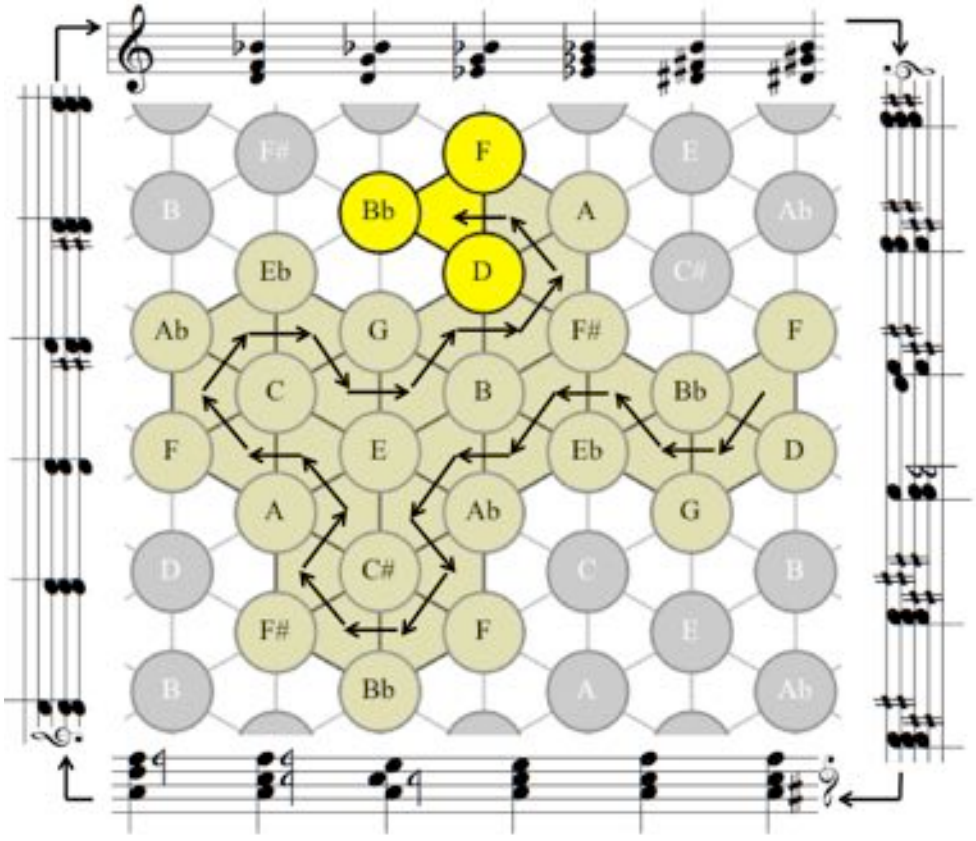
Socchiusa è la finestra, sul giardino.
Un'ora passa lenta, sonnolenta.
Ed ella, ch'era attenta, s'addormenta
A quella voce che già si lamenta,
Che si lamenta in fondo a quel giardino.

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'april quasi una neve
che sia tiepida.)
Ed ella certo deve soffrire,
Vagamente, anche nel sonno.



G. D'Annunzio (1863-1938)



ACTIONS Math'n'pop

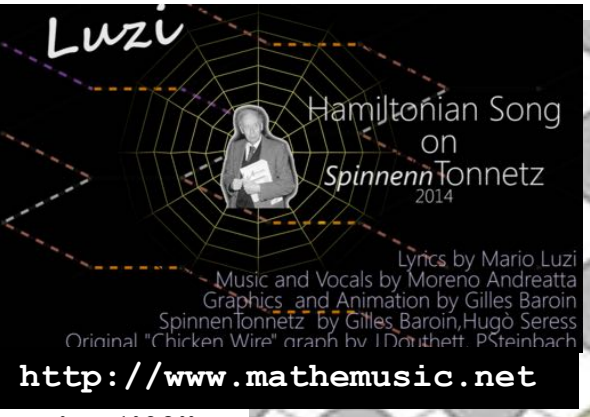
Aprile (d'après Gabriele D'Annunzio)

Tangente pour mieux comprendre le monde L'aventure mathématique

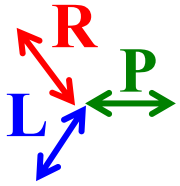
Hamiltonian Cycles with inner periodicities

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

L P L P L R …
P L P L R L …
L P L R L P …
P L R L P L …
L R L P L P …
R L P L P L …



min. 1’02”



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

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

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

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

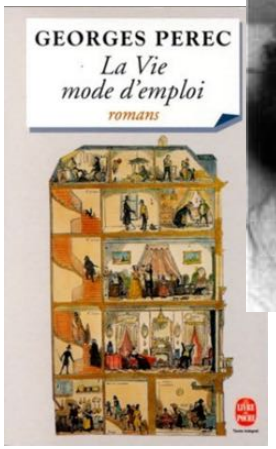
Caduto è più che un segno della vita,
riposi, dal viaggio sei tornata
dentro di te, sei scesa in questa pura
sostanza così tua, così romita
nel silenzio dell’essere, (compiuta).

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


Luzi
Hamiltonian Song
on
SpinnennTonnetz
2014
Lyrics by Mario Luzi
Music and Vocals by Moreno Andreatta
Graphics and Animation by Gilles Baroin
SpinnenTonnetz by Gilles Baroin,Hugò Seress
Original "Chicken Wire" graph by J.Douthett, P.Steinbach

The use of constraints in arts

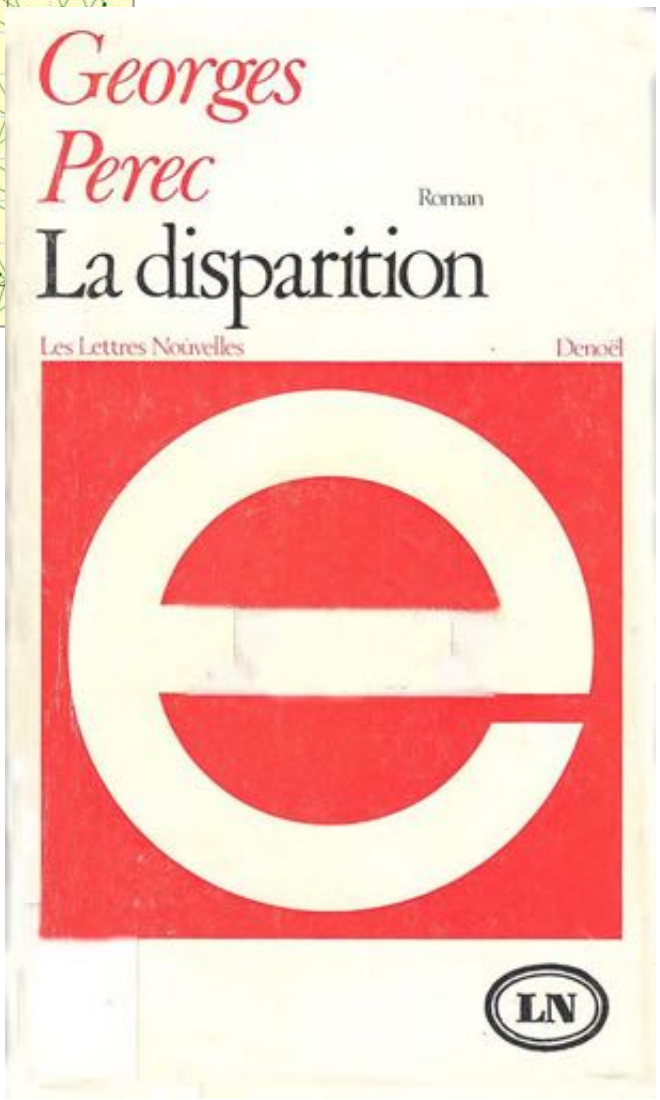
Cent mille milliards de poèmes, 1961



Georges Perrec

La vie mode d'emploi,

OuLiPo (Ouvroir de Littérature Potentielle)



Raymond Queneau

Italo Calvino

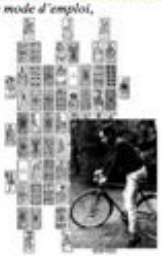
Il castello dei destini incrociati, 1969

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

Cent mille milliards de poèmes, 1961

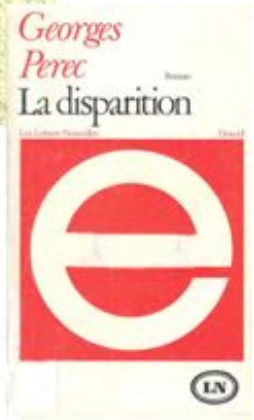
La vie mode d'emploi,

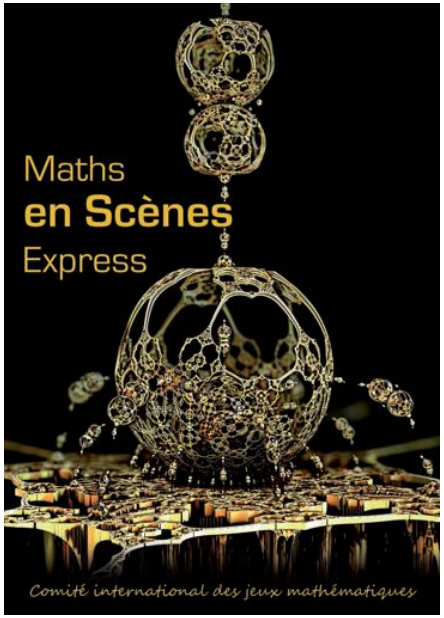
Raymond Queneau



Italo Calvino

Le Château des destins croisés, 1969





http://oumupo.org/

Valentin Villenave

Mike Solomon

Jean-François Piette

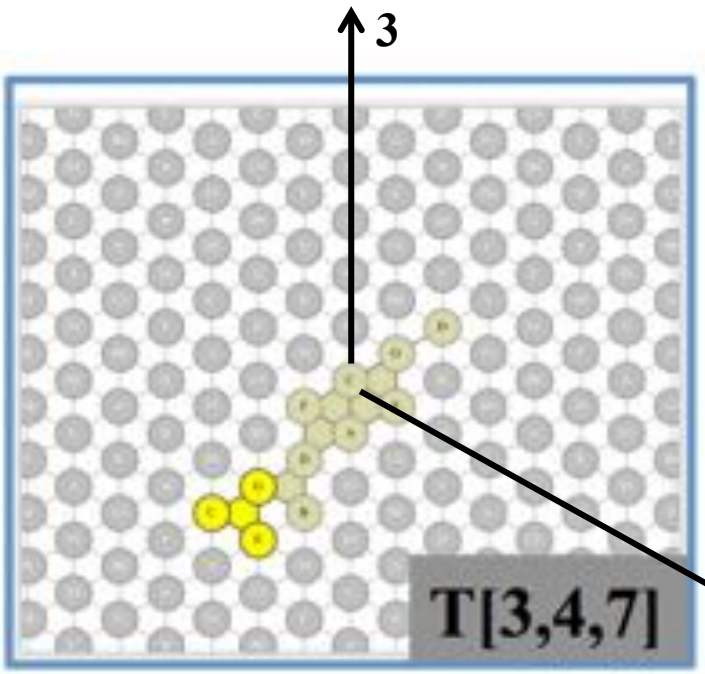
Martin Granger

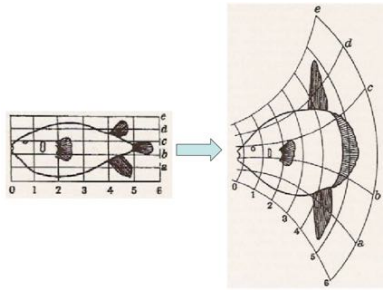
Joseph Boisseau

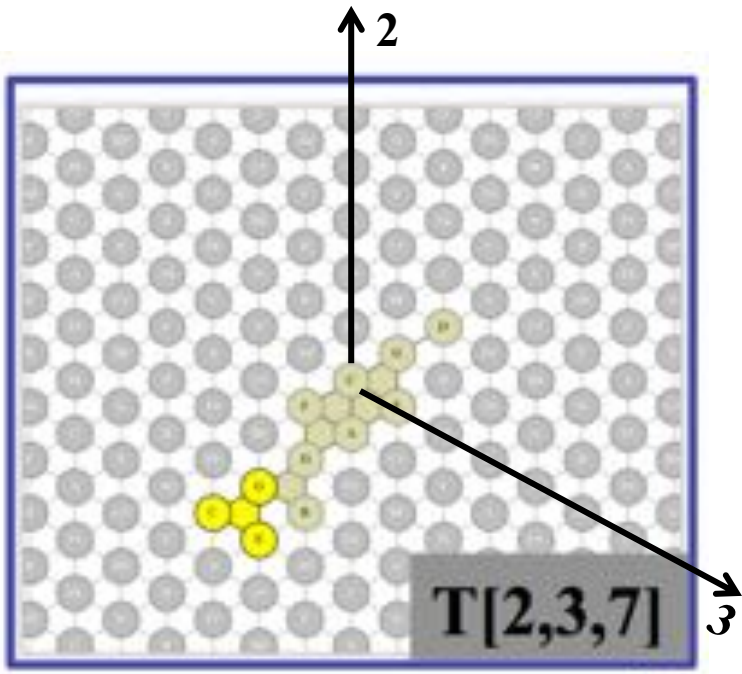
Moreno Andreatta

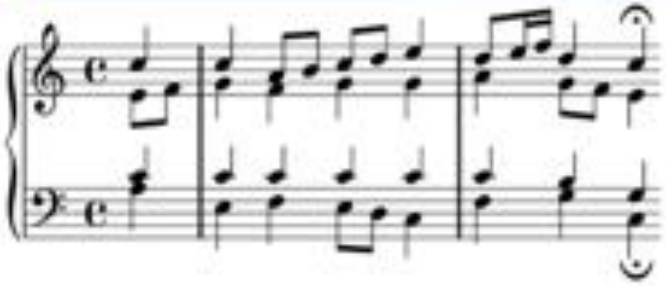
Tom Johnson

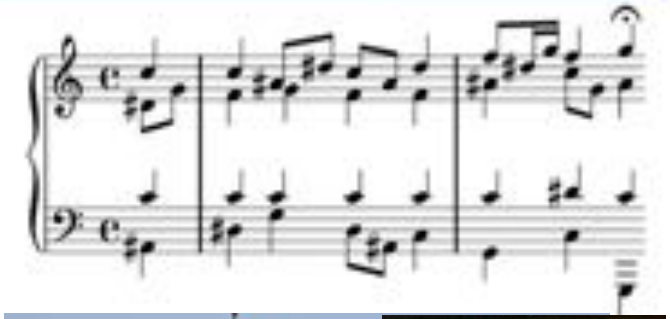
The musical style...is the space!



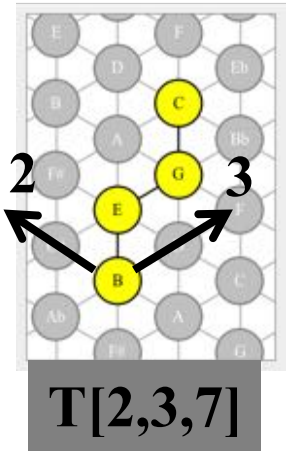


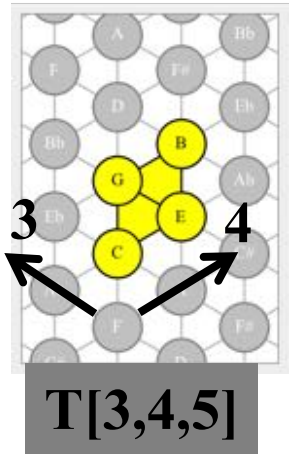


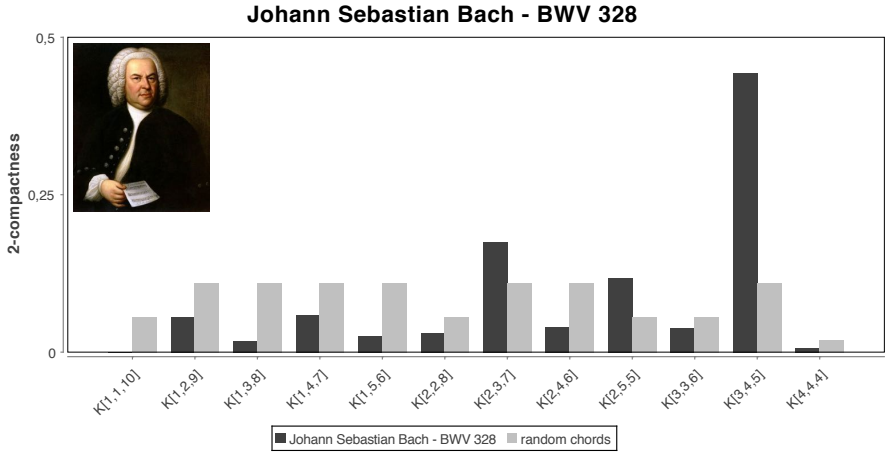


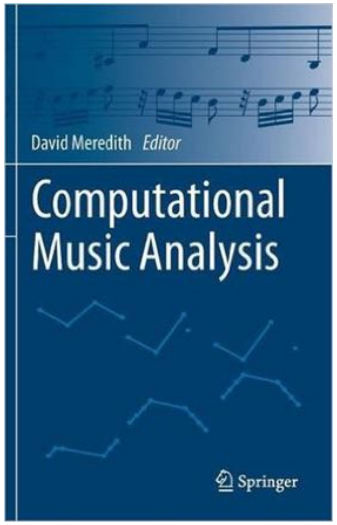


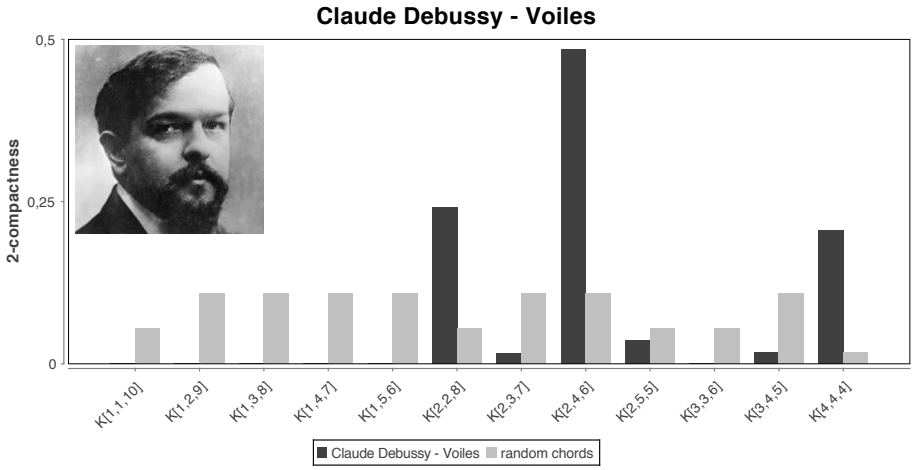
The geometric character of musical logic

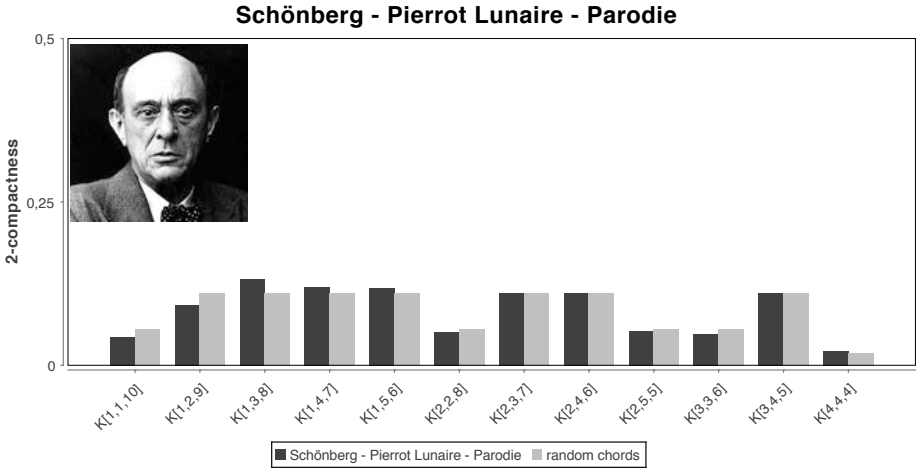




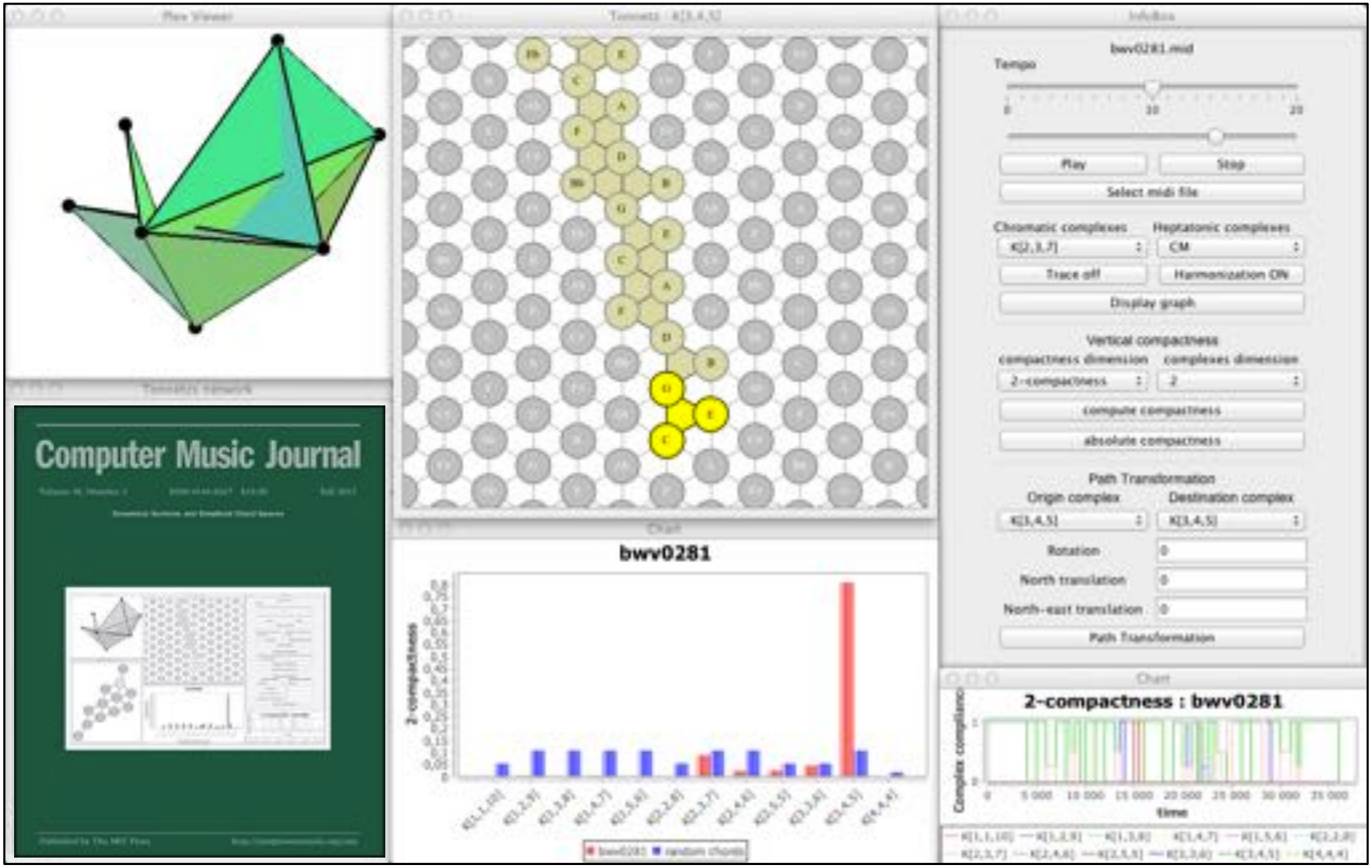








Spatial music analysis via Hexachord



➔**http://www.lacl.fr/~lbigo/hexachord**


Thank you for your attention!