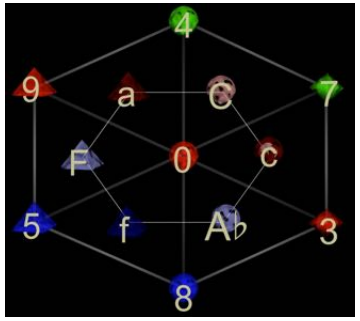
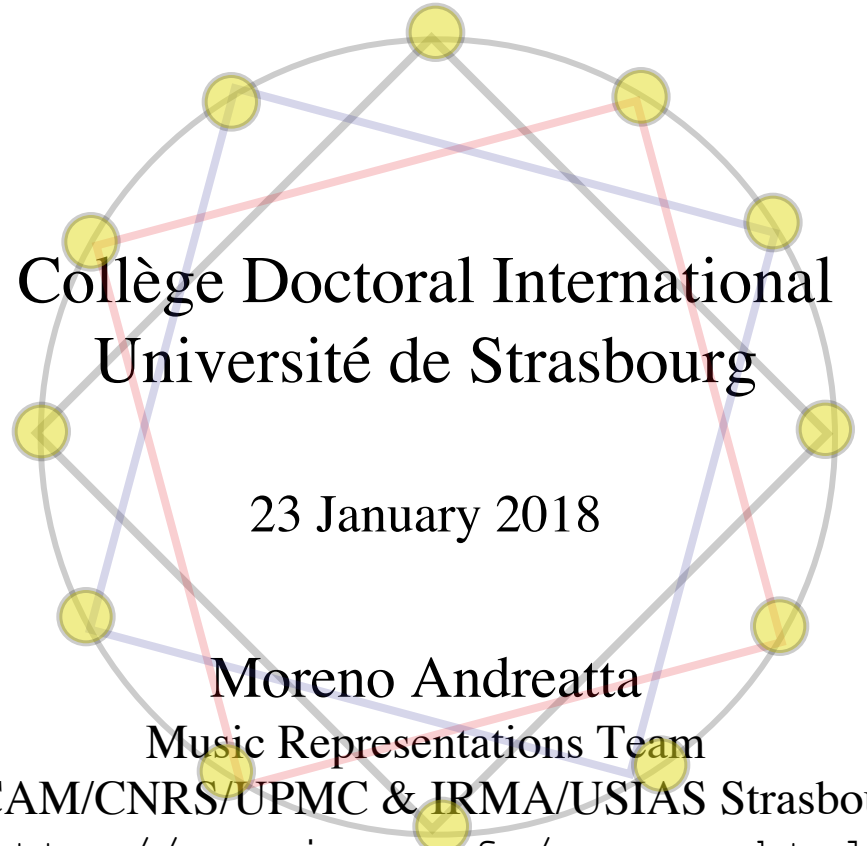
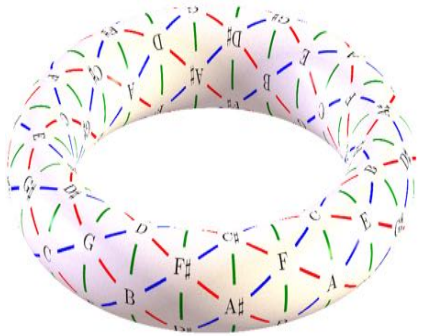
Computational Musicology between scientific research and artistic practice







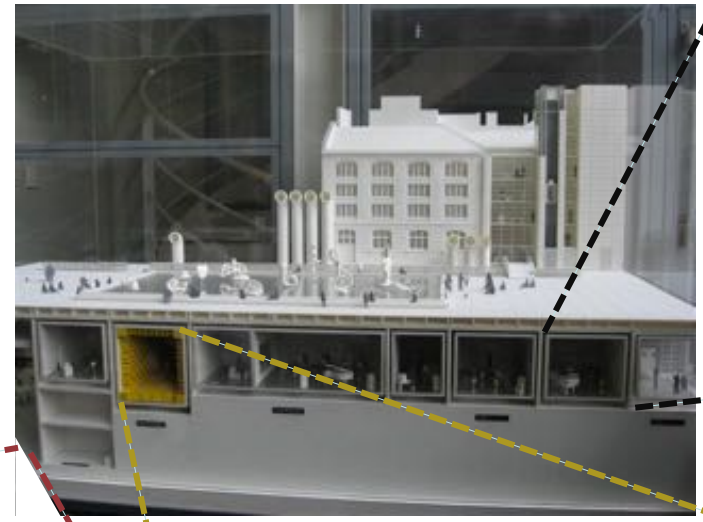
Collège Doctoral International
Université de Strasbourg

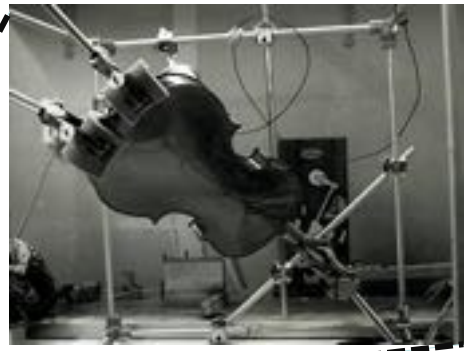
23 January 2018

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

ircam Centre Pompidou · cnrs · SORBONNE UNIVERSITÉ · IRMA Institut de Recherche Mathématique Avancée · GREAM · USIAS Université de Strasbourg Institut d'Études Avancées

The musical and scientific research at IRCAM...





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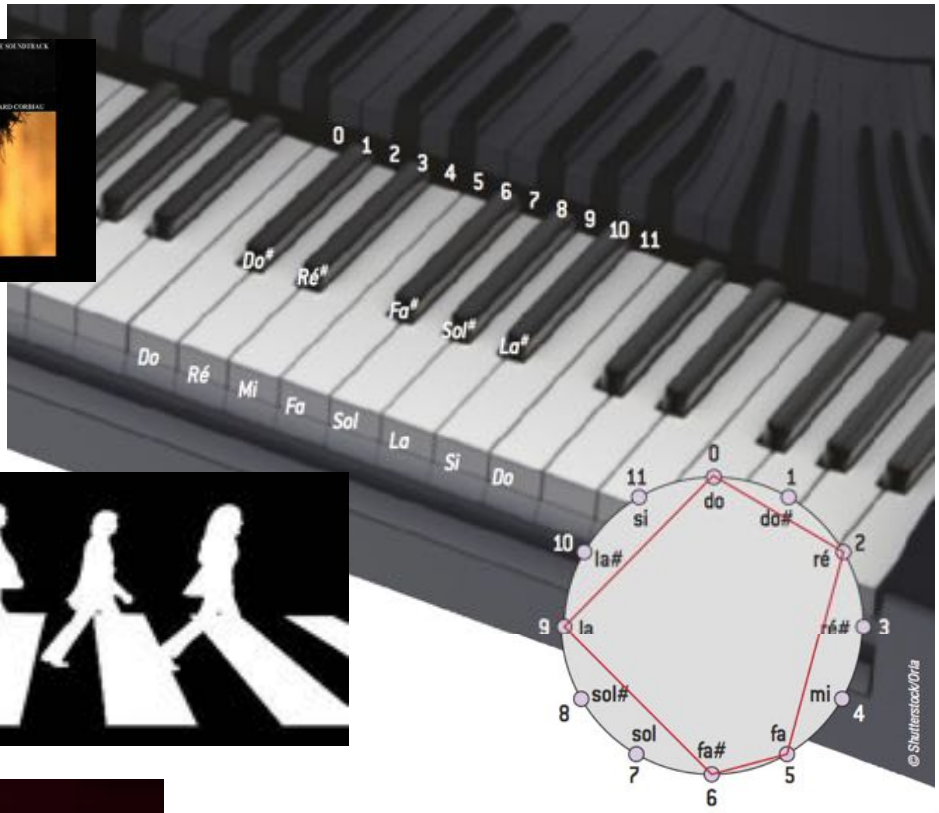
... at the interface between art and popular music

MusiqueLab 2



OMAX (computer-aided impro)

Orig.

Var. 1 Var. 2

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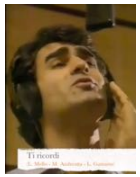
My personal path through maths and art/popular music

- **1993-1996** Music analysis, composition and conducting (Trento) + electronic music (University of Milan) + mathematics (University of Pavia)
- **1996-1997** *Visiting Student* (Brighton, UK)
- **1997-1998** Professional training « composer and arrangeur of applied music » and contemporary music composition courses (Milan)
- **1998** Piano diploma (Conservatory of Novara, Italy)
- **1998-2003** Master 2 (DEA) and PhD in Musicology at the EHESS / IRCAM and piano-bar pianist (Bateaux Parisiens, until 2009)
- **2004** Recruitment from CNRS (chargé de recherche en 1ere classe)
- **2005-2009** Pianist-singer and artistic director of the *N91* music group
- **2010** HDR in mathematics and its interactions (IRMA, Strasbourg)
- **Since 2012** Coordinator of the ATIAM (Acoustique, Traitement du signal et informatique appliqués à la musique) Master Program
- **Since 2016** Research Director at the CNRS and USIAS fellow (SMIR Project – Structural Music Information Research)



cnrs

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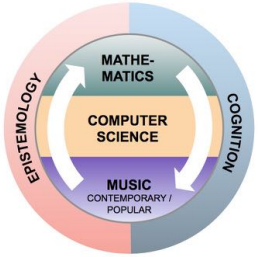
ATIAM



Some examples of PhD on maths & music

- **Alessandro Ratoci**, Vers l'hybridation stylistique assistée par ordinateur, PhD in music **composition & research**, Sorbonne University / IRCAM (cosupervised with Laurent Cugny)
- **Sonia Cannas**, *Représentations géométriques et formalisations algébriques en musicologie computationnelle*, PhD in **maths** in cotutelle agreement, **University of Pavia** (L. Pernazza) / **Université de Strasbourg** (A. Papadopoulos & M. Andreatta). To be defended in 2019.
- **Grégoire Genuys**, *Théorie de l'homométrie et musique*, PhD in **maths**, **Sorbonne University** / IRCAM (cosupervised with Jean-Paul Allouche), 2017.
- **Hélianthe Caure**, *Pavages en musique et conjectures ouvertes en mathématiques*, PhD in **computer science**, **Sorbonne University** (cosupervised with Jean-Paul Allouche), 2016.
- **Mattia Bergomi**, *Dynamical and topological tools for (modern) music analysis,* PhD in **maths** in a cotutelle agreement Sorbonne University / University of Milan (cosupervised with Goffredo Haus, 2015).
- **Charles De Paiva**, *Systèmes complexes et informatique musicale*, thèse de doctorat, Programme Doctoral International « Modélisation des Systèmes Complexes », PhD in **musicology** in a cotutelle agreement, **Sorbonne University** / **UNICAMP**, Brésil, 2016.
- **John Mandereau**, *Des systèmes d'Intervalles Généralisés aux Systèmes Evolutifs à Mémoire : aspects théoriques et computationnels*, thèse de doctorat en mathématiques, PhD in cotutelle agreement **University of Pisa** / **Sorbonne University** (cosupervised with F. Acquistapace). PhD in **maths** (aborted).
- **Louis Bigo**, *Représentation symboliques musicales et calcul spatial*, PhD in **computer science**, **University of Paris Est Créteil** / **IRCAM**, 2013 (cosupervised with Olivier Michel and Antoine Spicher)
- **Emmanuel Amiot**, *Modèles algébriques et algorithmiques pour la formalisation mathématique de structures musicales*, PhD in, **Sorbonne University** / **IRCAM**, 2010 (cosupervised with Carlos Agon) **computer science**
- **Yun-Kang Ahn**, *L'analyse musicale computationnelle*, PhD in **computer science**, **Sorbonne University** / **IRCAM**, 2009 (cosupervised with Carlos Agon)

UNIVERSITÉ DE STRASBOURG

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UPEC Connaissance - Action | UNIVERSITÉ PARIS-EST CRÉTEIL VAL DE MARNE

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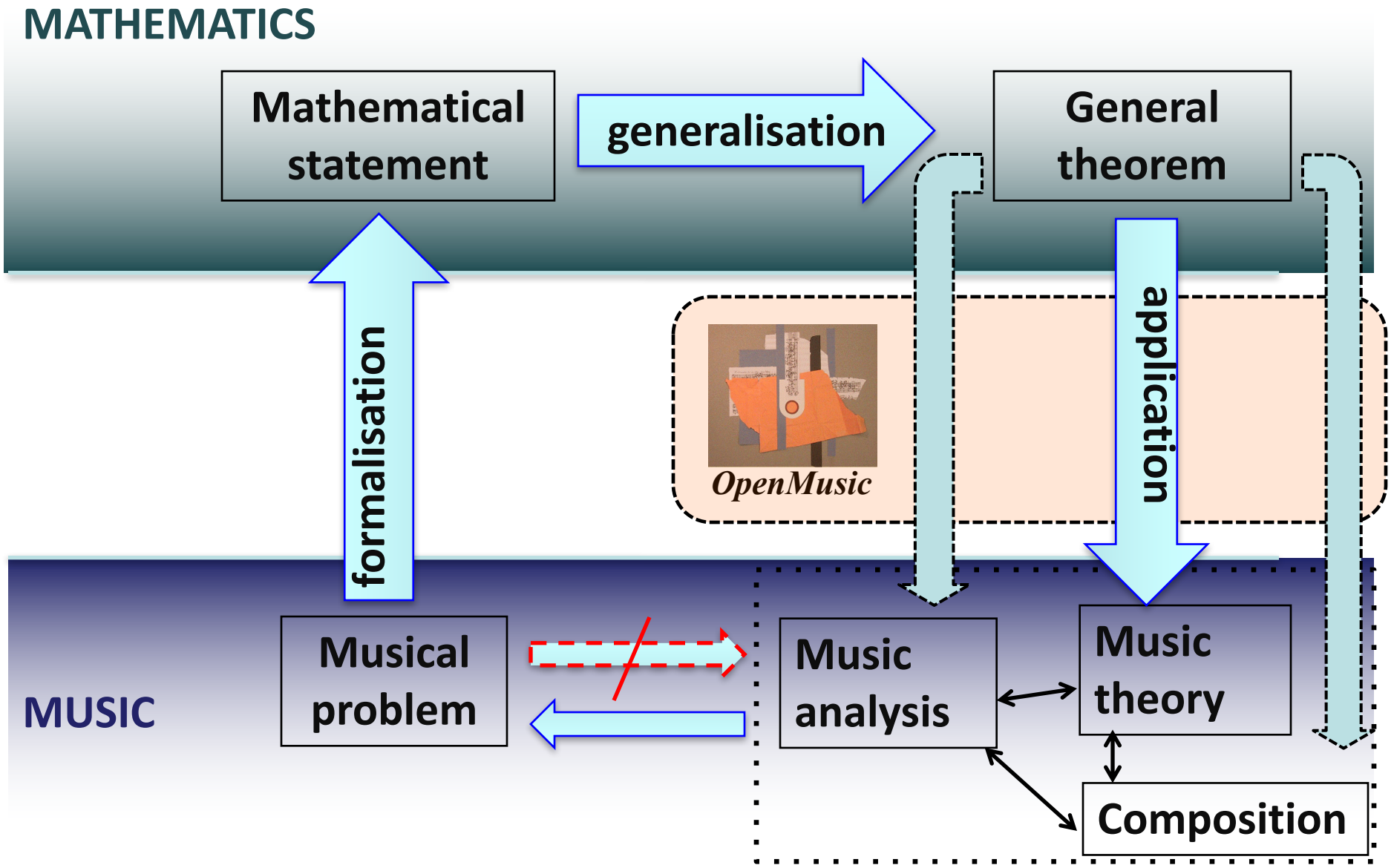
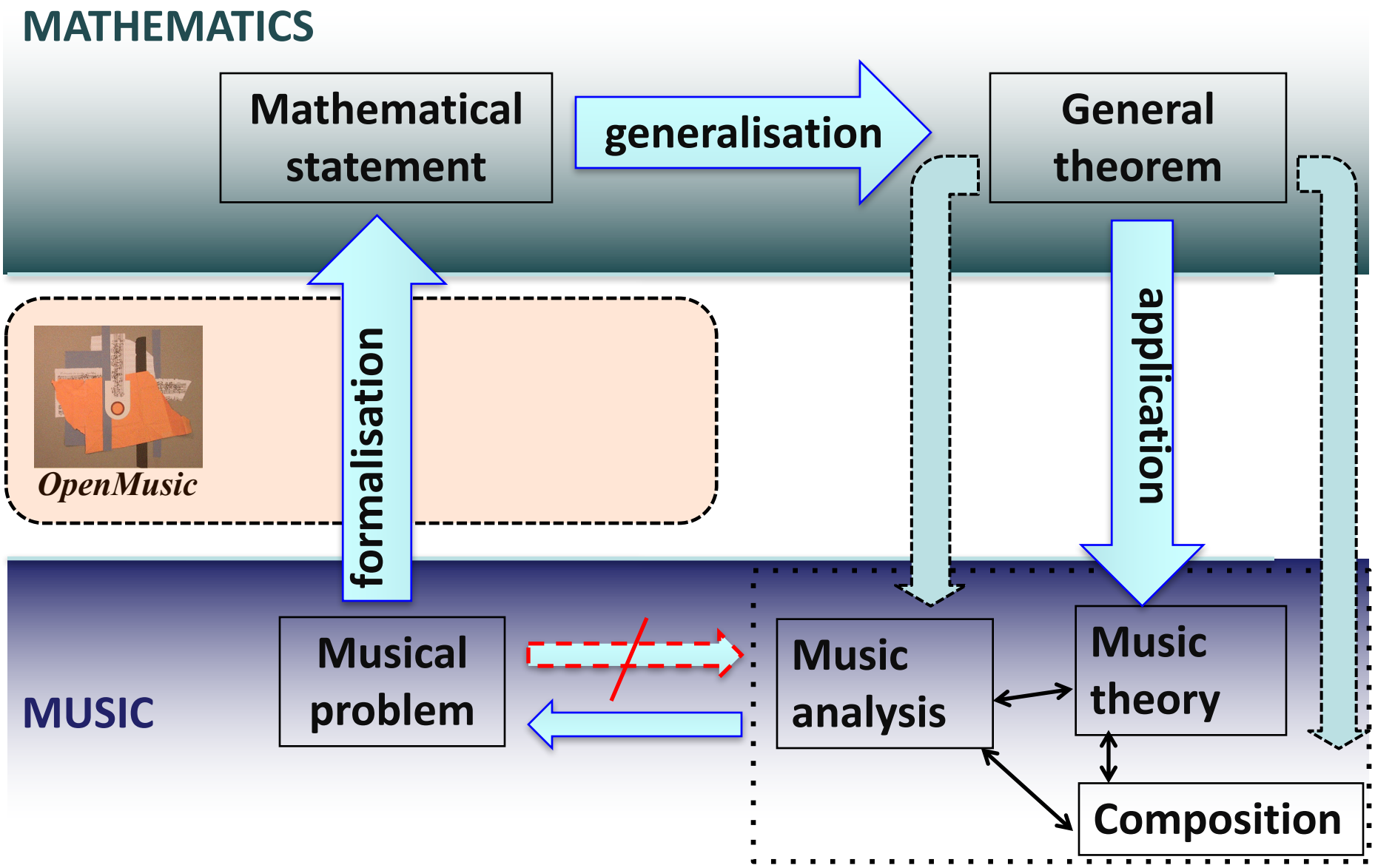
The double movement of a ‘mathemusical’ activity



The double movement of a ‘mathemusical’ activity



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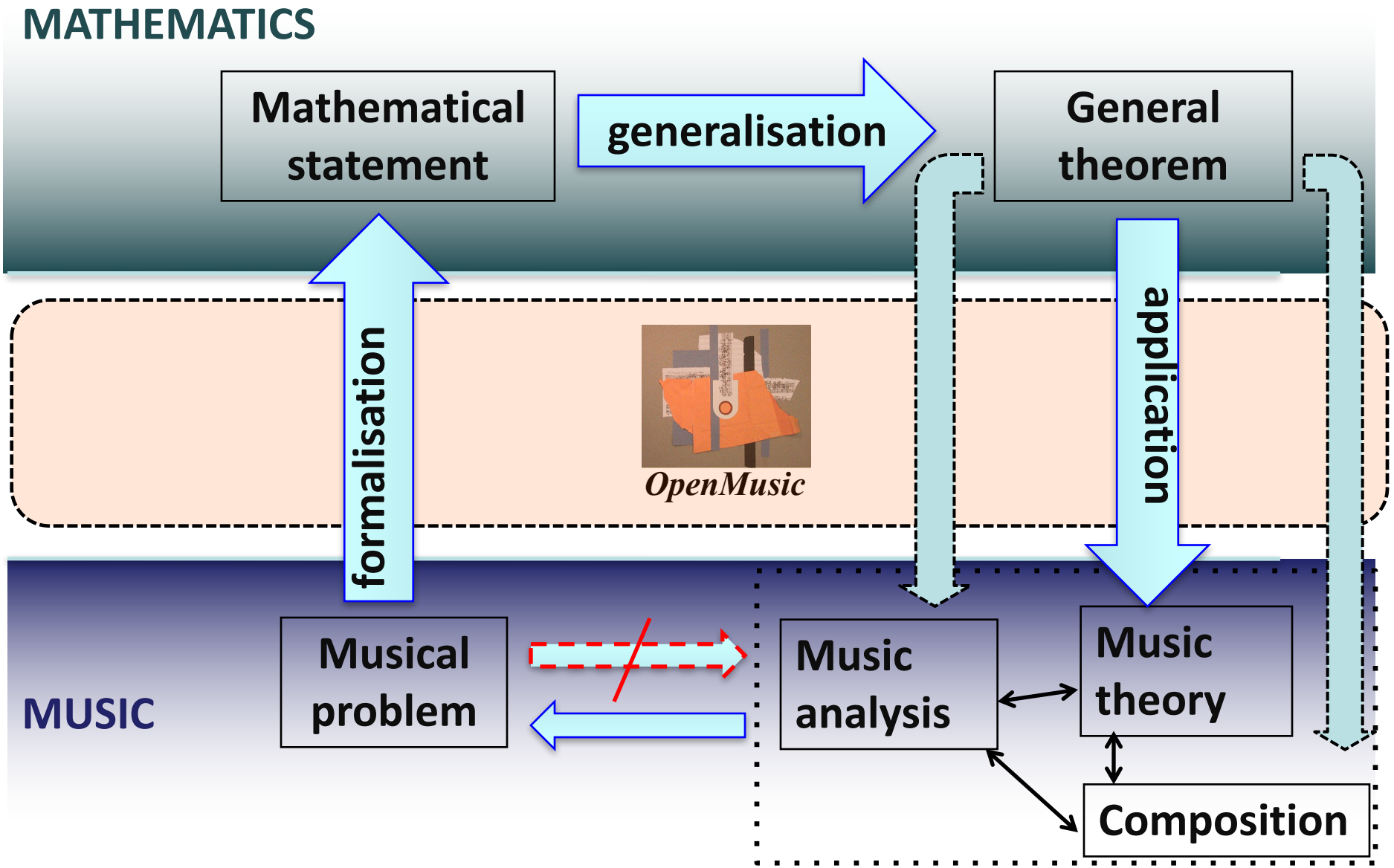
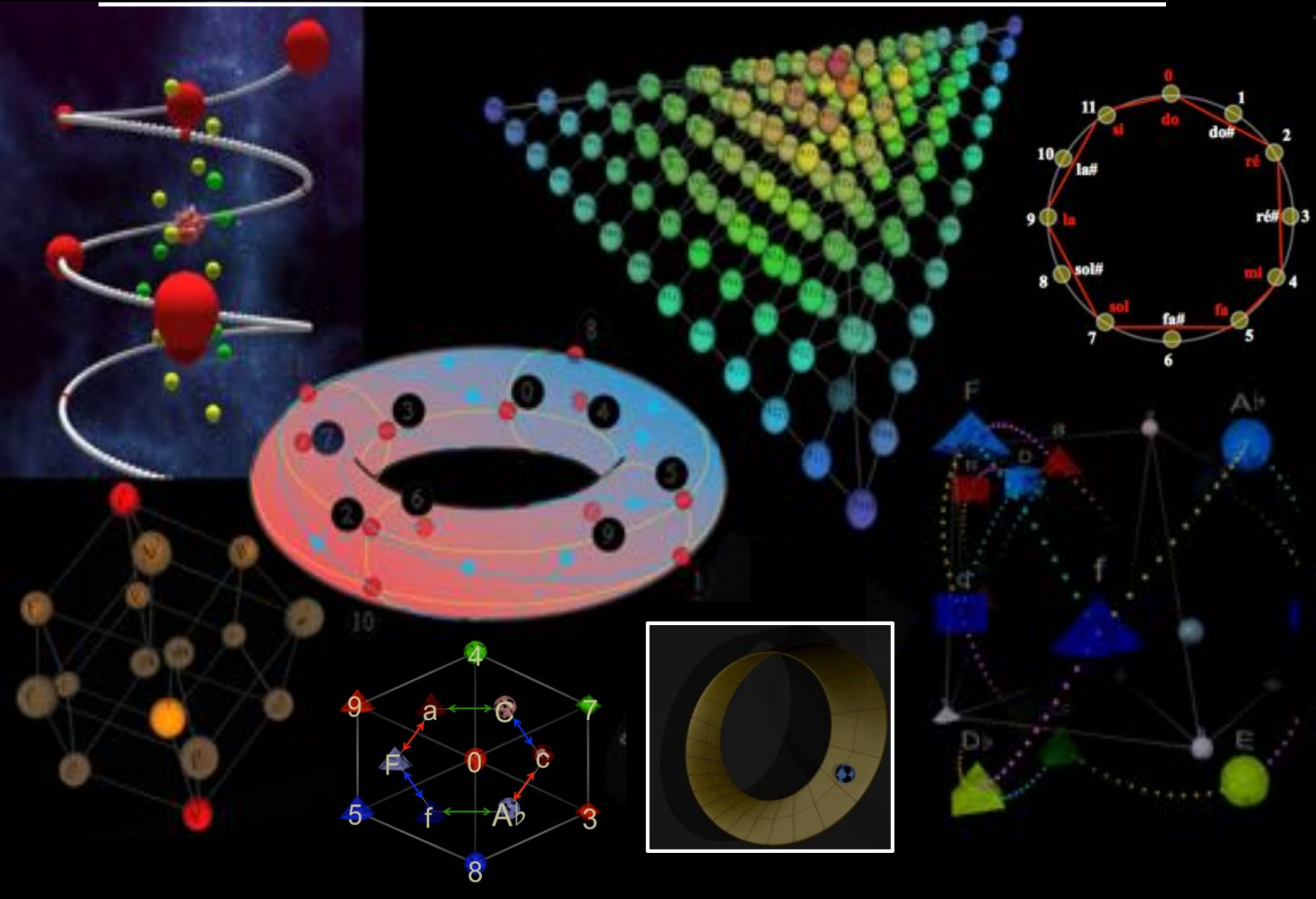


The galaxy of geometrical models at the service of music



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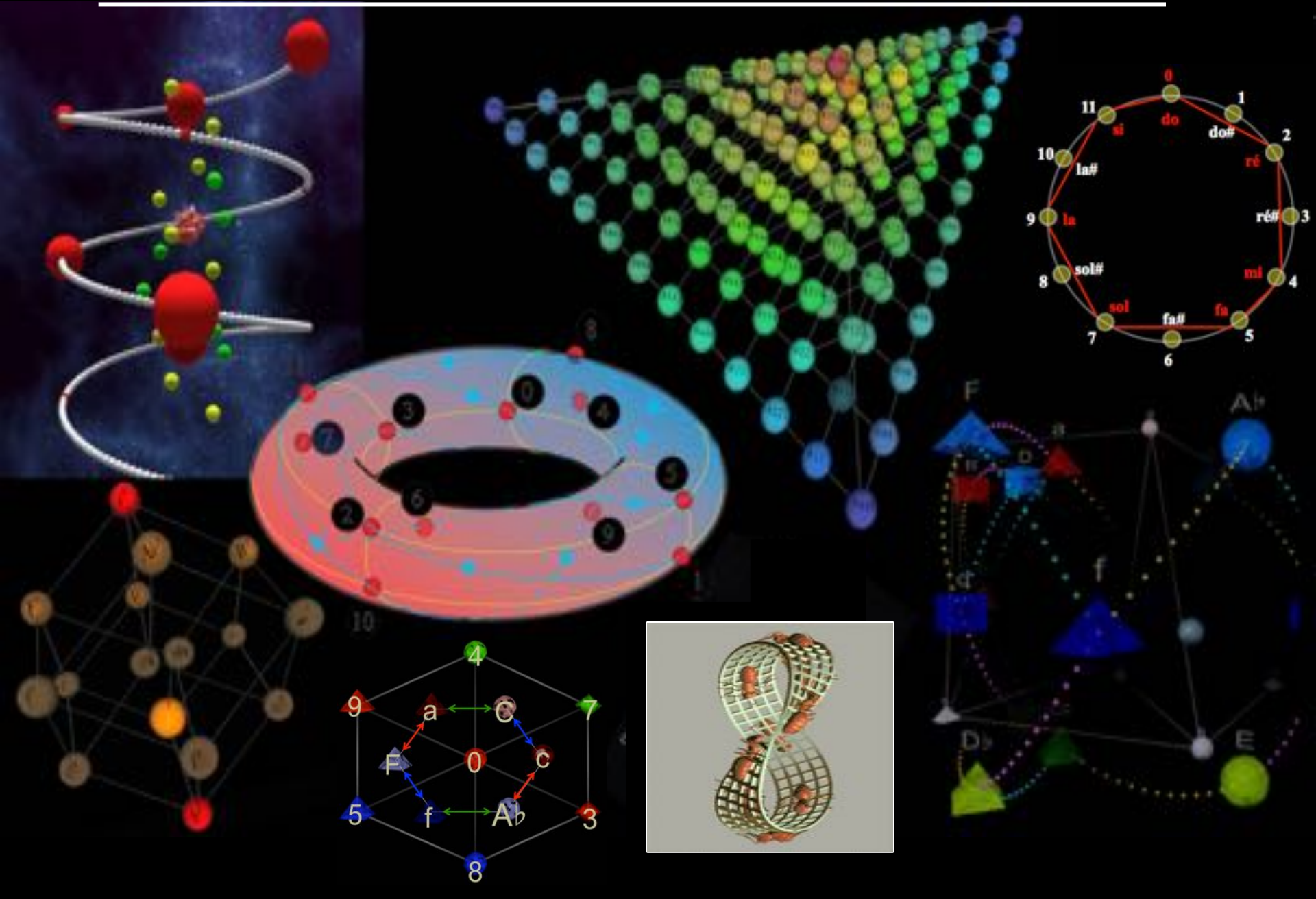
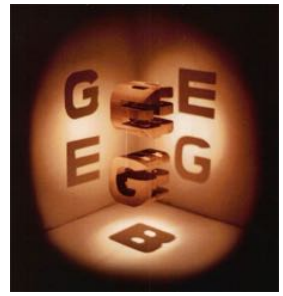
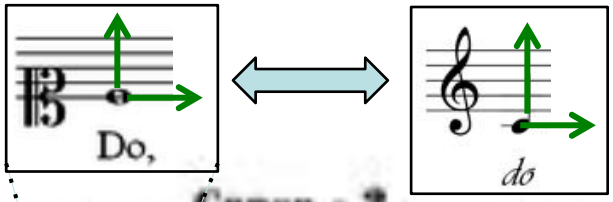
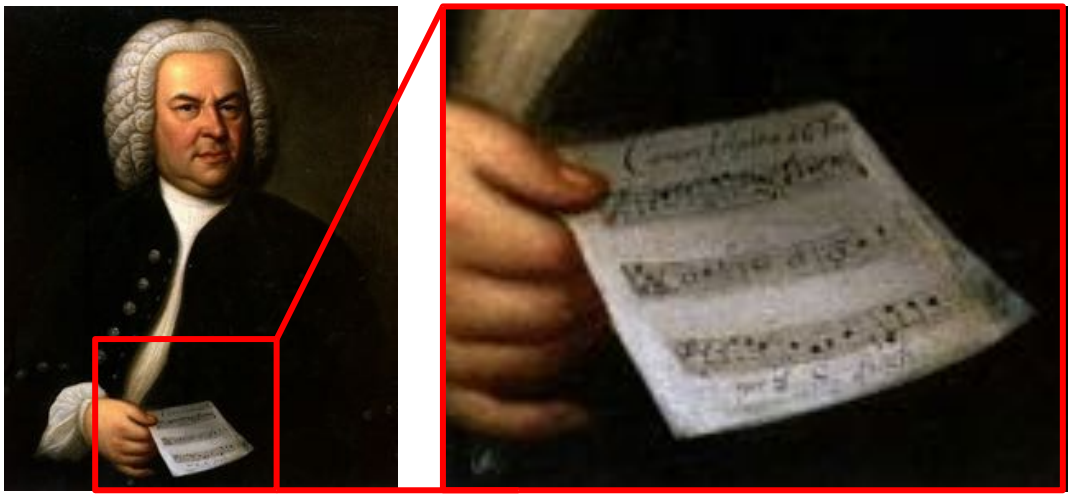


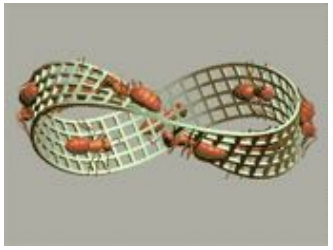
Bach's enigmatic canons and geometry

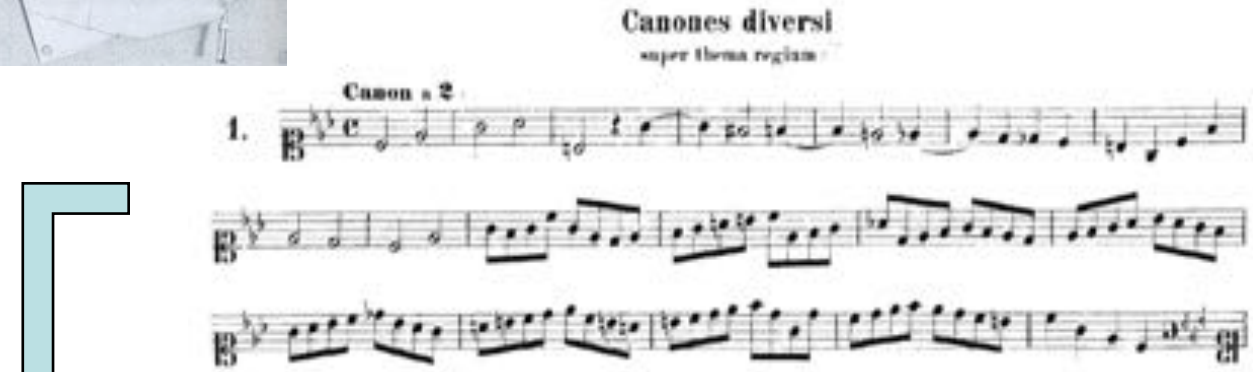


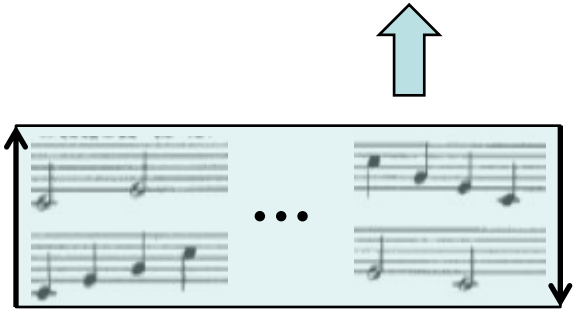




My end is my beginning (but twisted!)







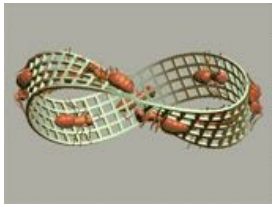
BACH

Musikalisches Opfer

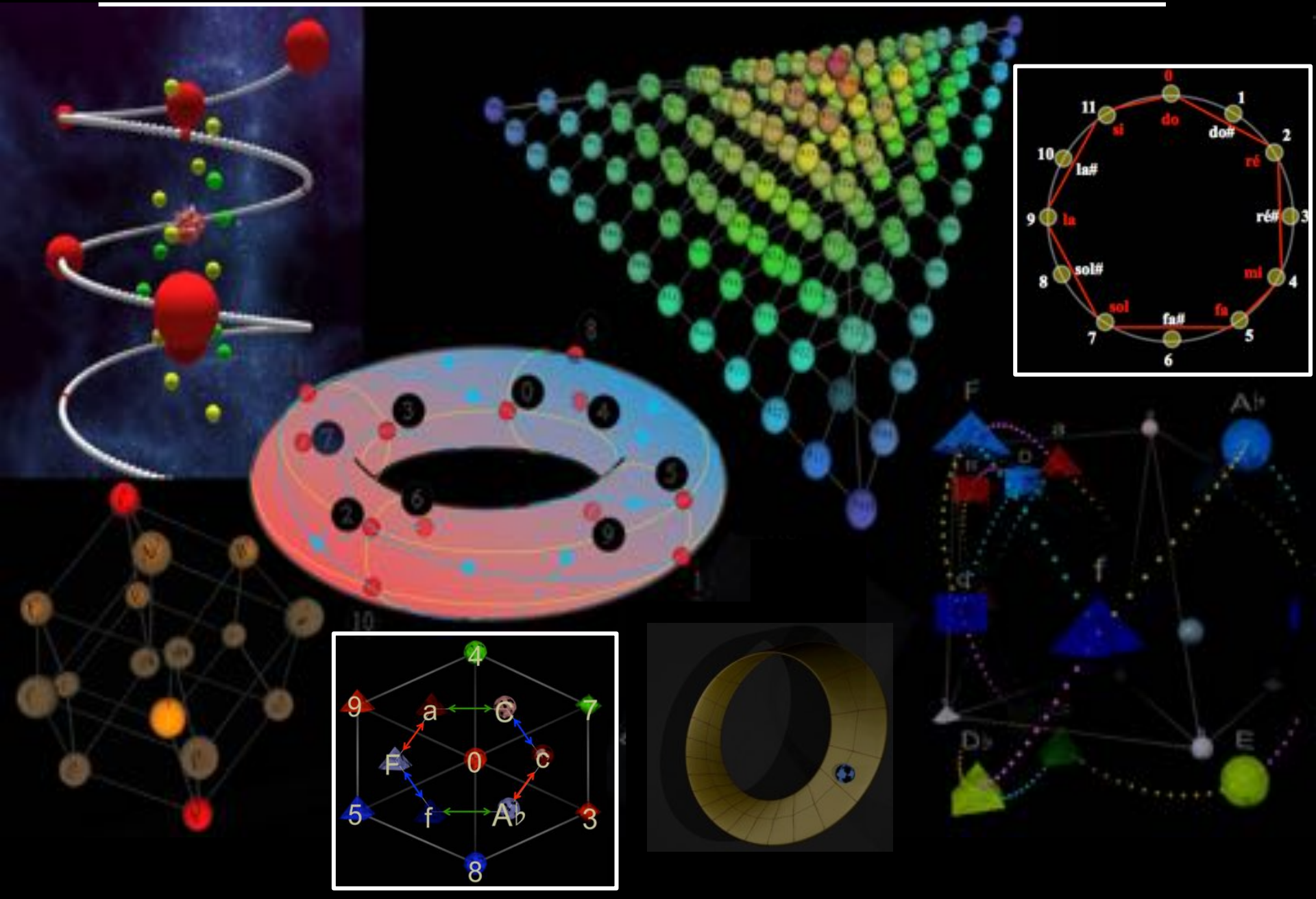
Musical Offering - Offrande Musicale

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

[min. 1’14”]



The galaxy of geometrical models at the service of music



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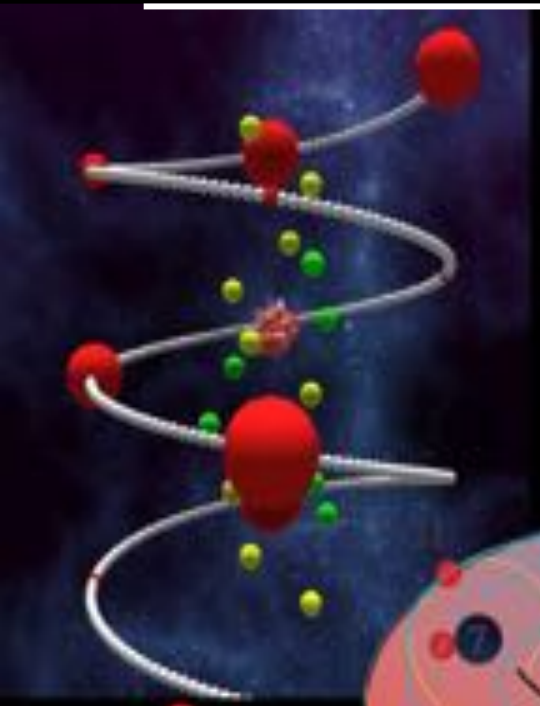
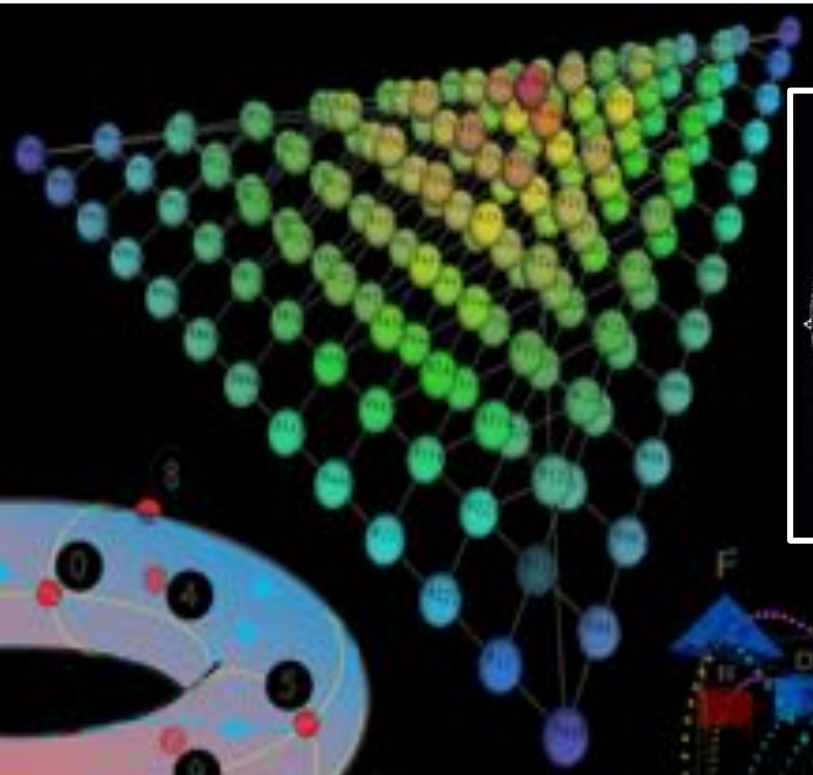
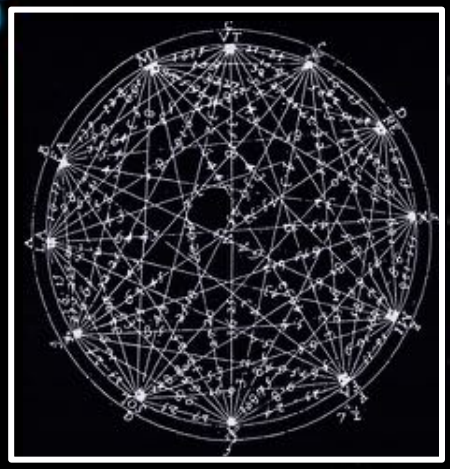
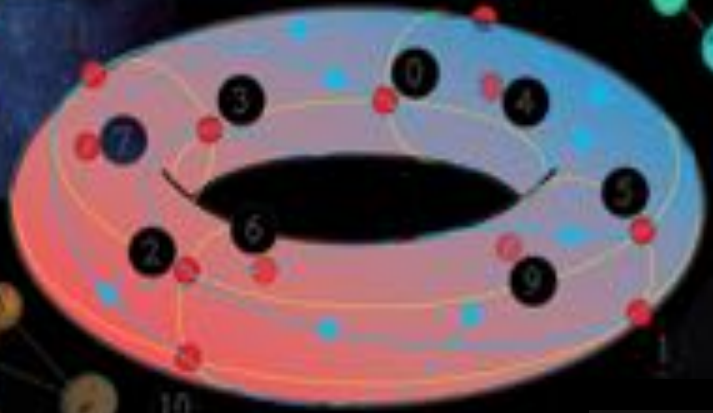
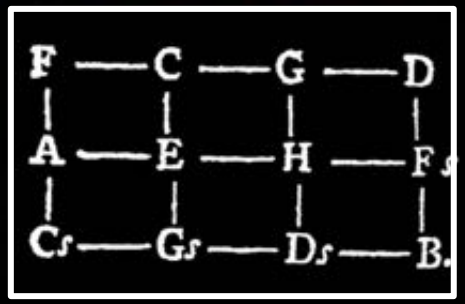
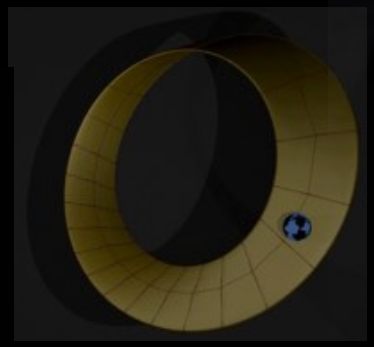






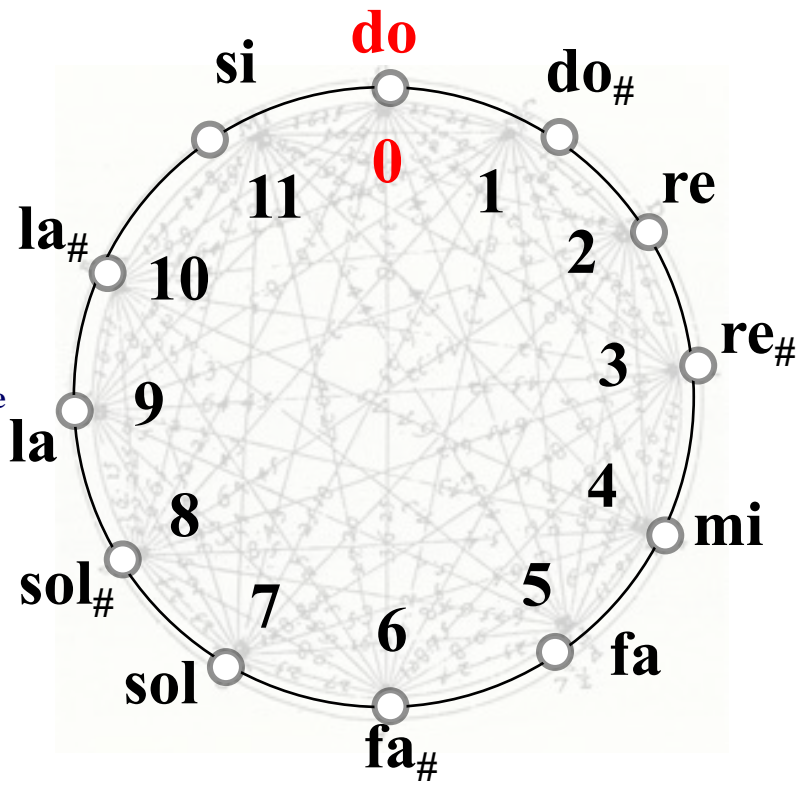




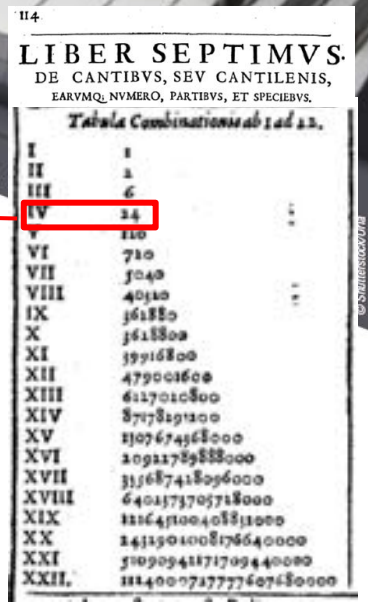


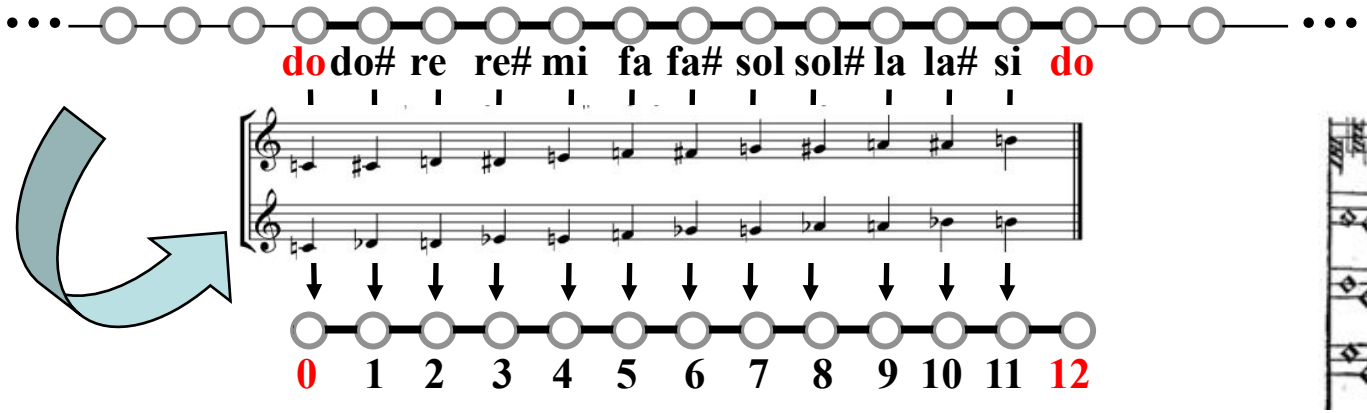
The circular representation of the pitch space

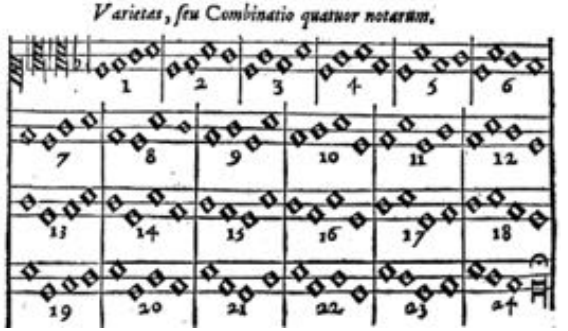
Marin Mersenne



Harmonicorum Libri XII, 1648







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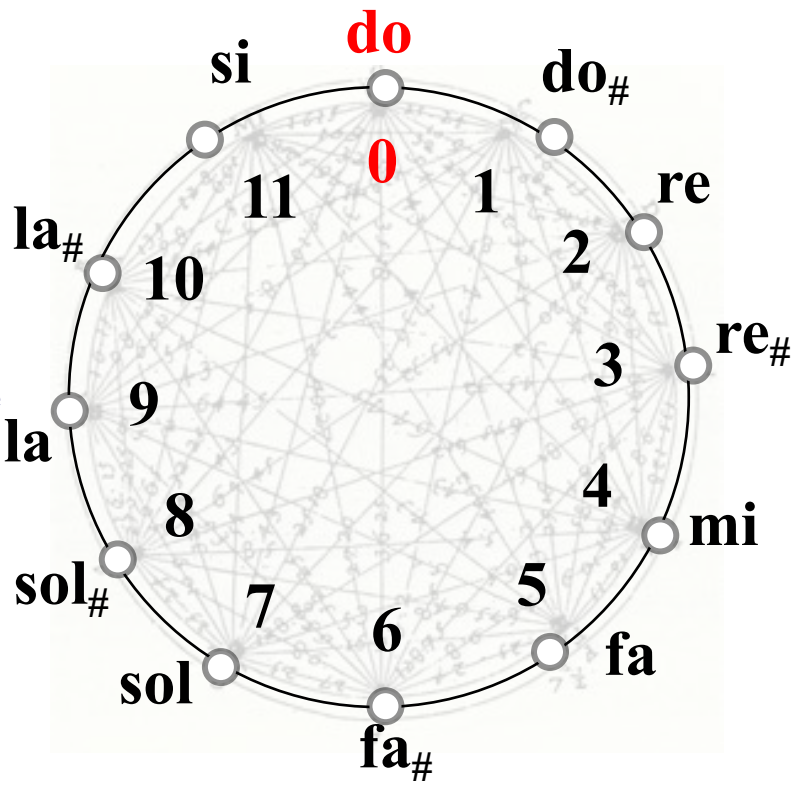

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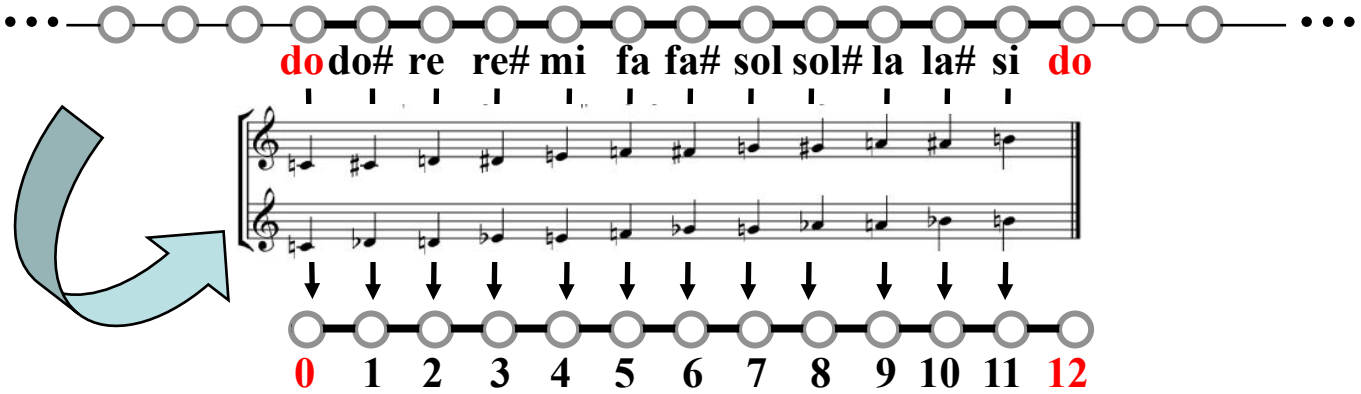

➔ DEMO

Permutational melodies in contemporary (art) music

114 **Marin Mersenne, *Harmonicorum Libri XII*, 1648**

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

Tabula Combinationis ab 1 ad 22.

I	1
II	2
III	6
IV	24
V	120
VI	720
VII	5040
VIII	40320
IX	362880
X	3628800
XI	39916800
XII	479001600
XIII	6227020800
XIV	87178291200
XV	1307674368000
XVI	20922789888000
XVII	355687428096000
XVIII	6402373705728000
XIX	121645100408832000
XX	2432902008176640000
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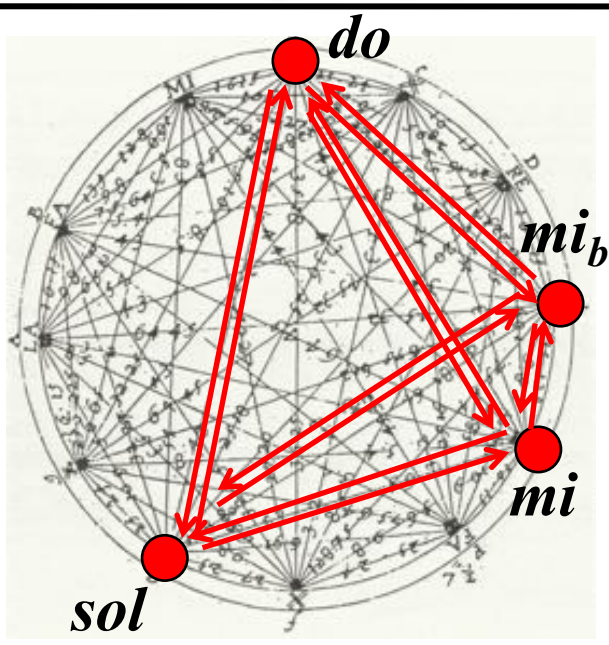
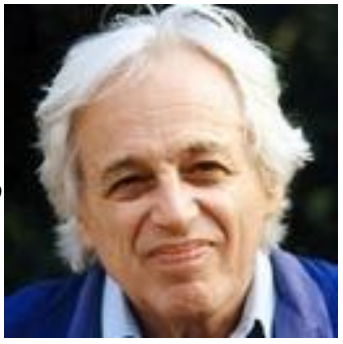
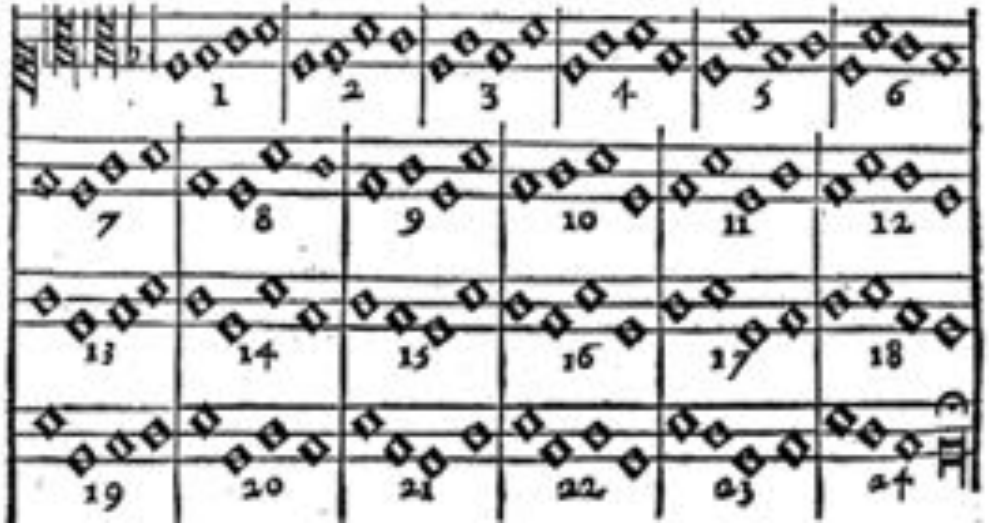
XXII.	1124000727777607680000





Six Bagatelles
(G. Ligeti, 1953)

Varietas, seu Combinatio quatuor notarum.



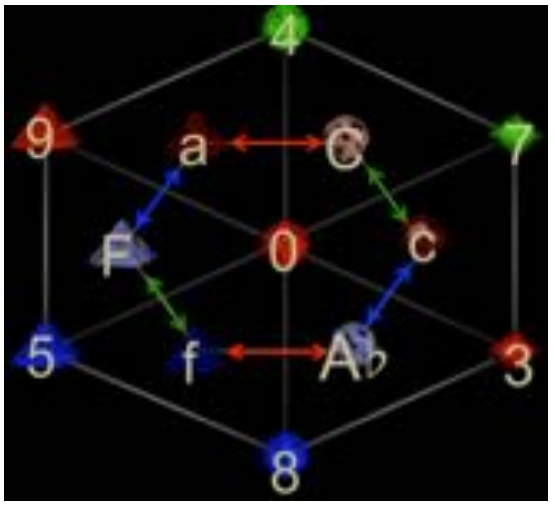
Permutational melodies in song writing

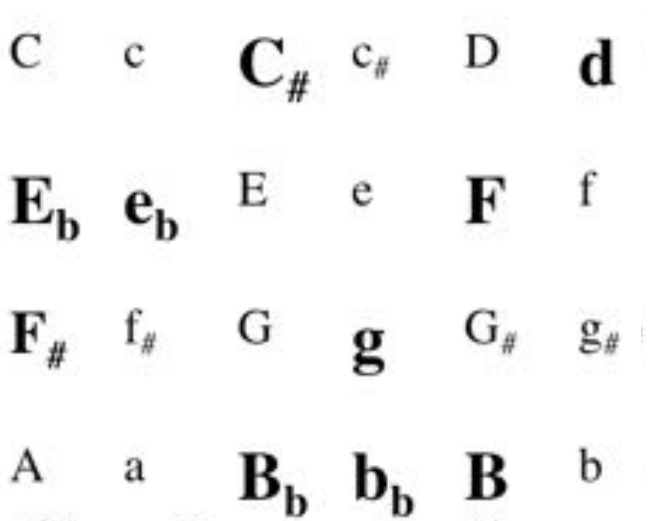
***Se telefonando*, 1966 (Maurizio Costanzo/Ennio Morricone) / Mina**

(min. 0'53")

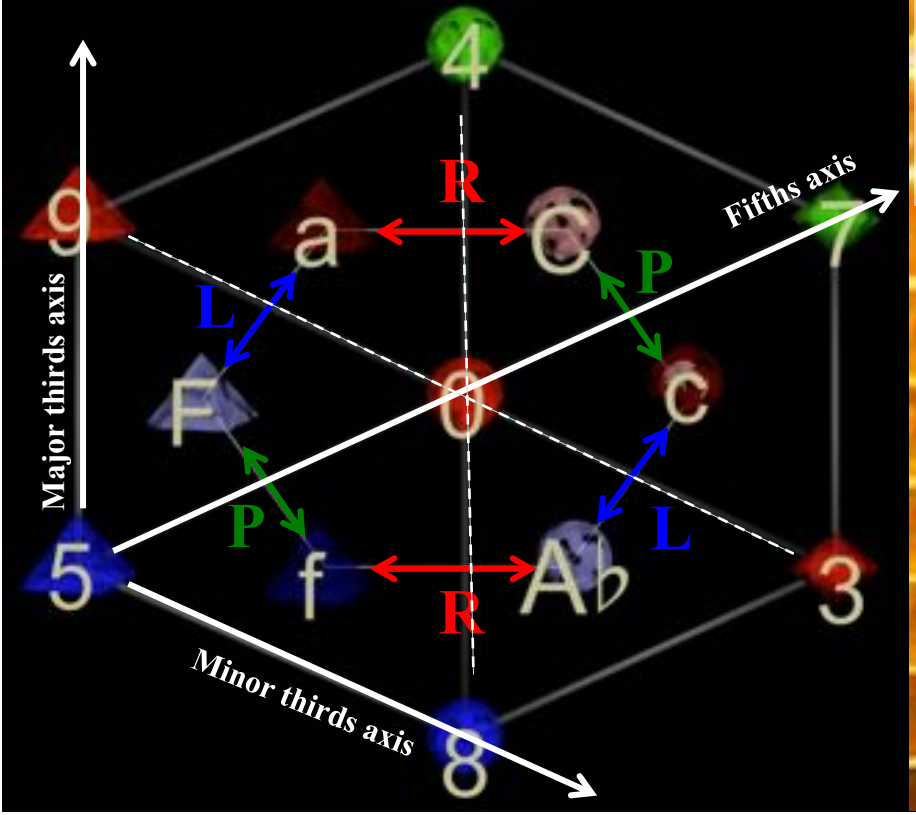
Ennio Morricone

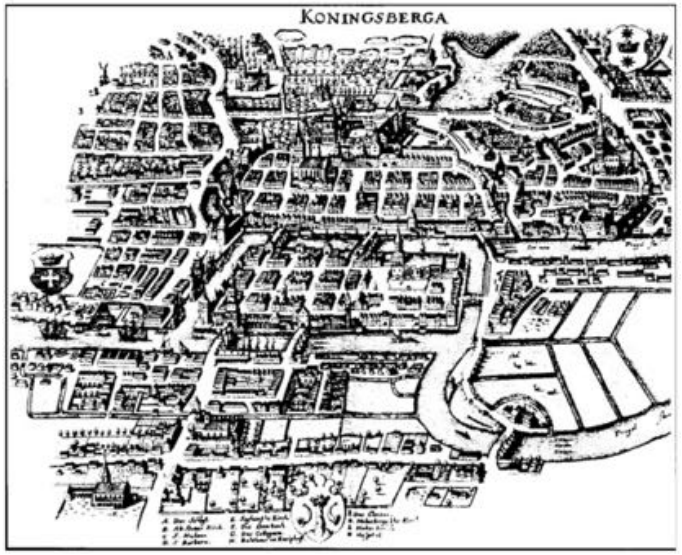
The harmonic space

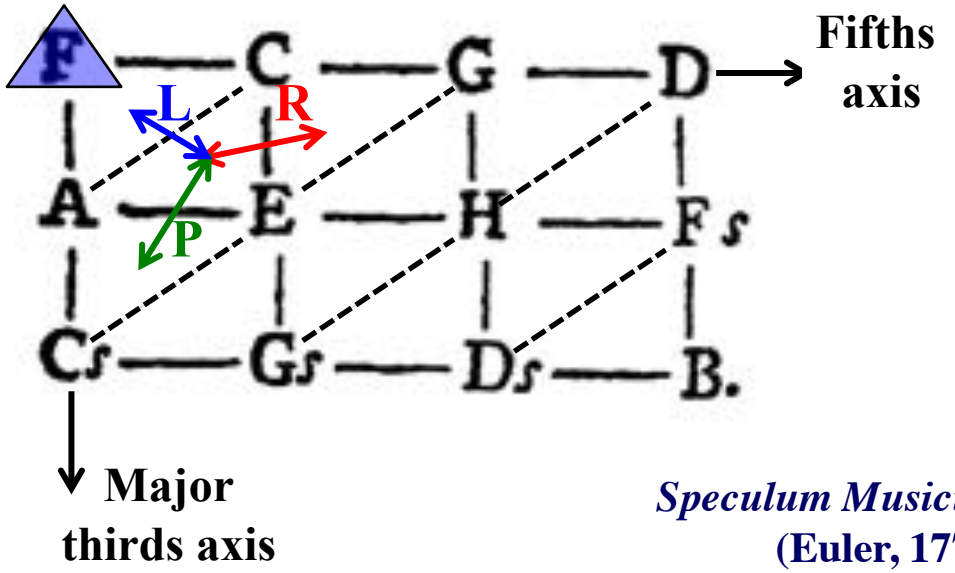




The *Tonnetz*
(or 'honeycomb' hexagonal tiling)

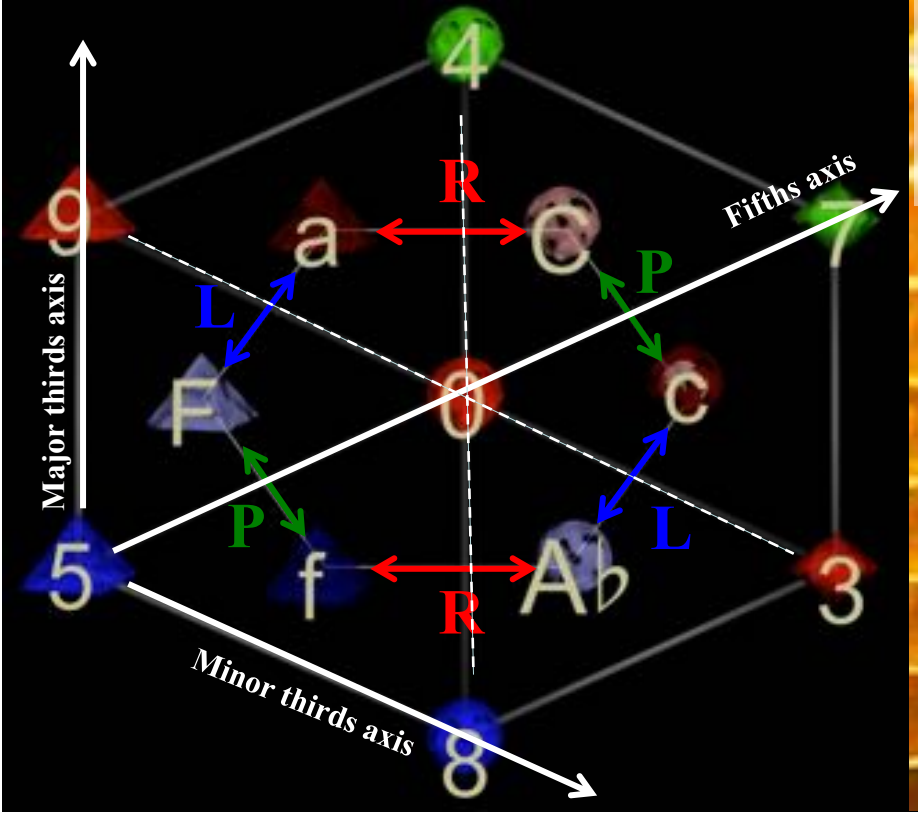


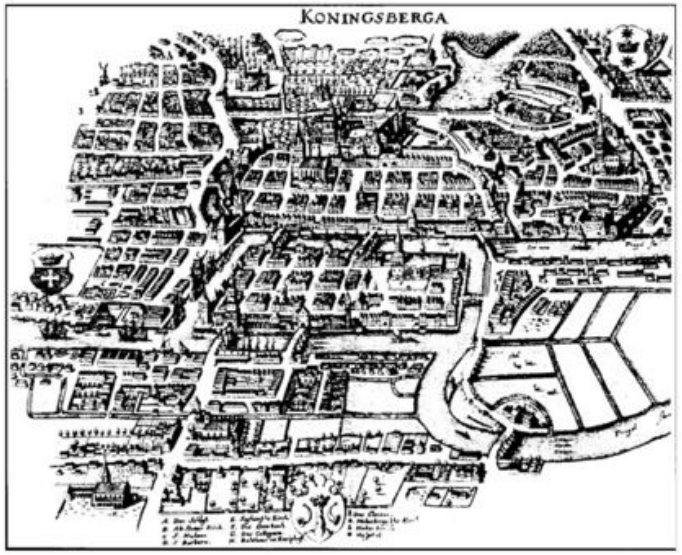


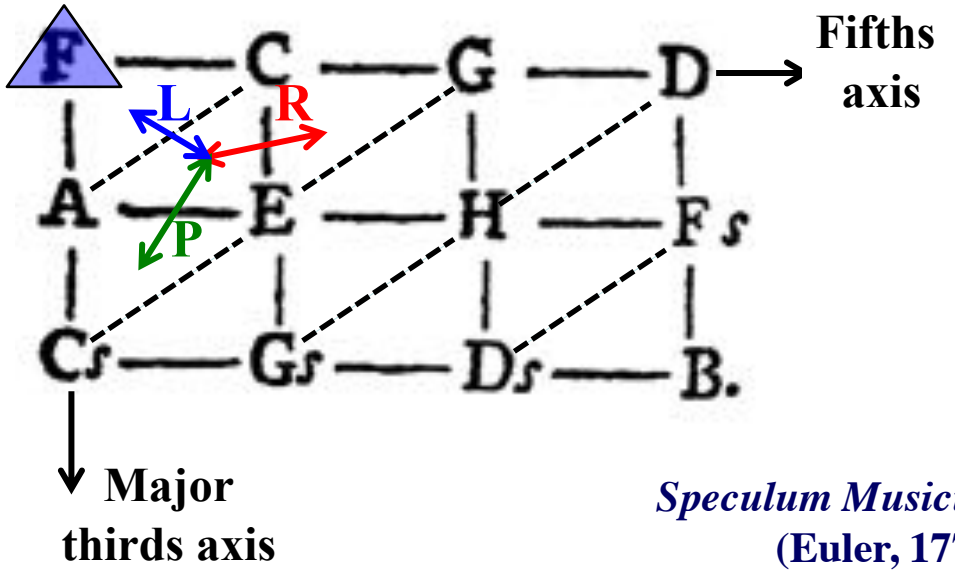


Speculum Musicum
(Euler, 1773)

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







Speculum Musicum
(Euler, 1773)

The *Tonnetz*
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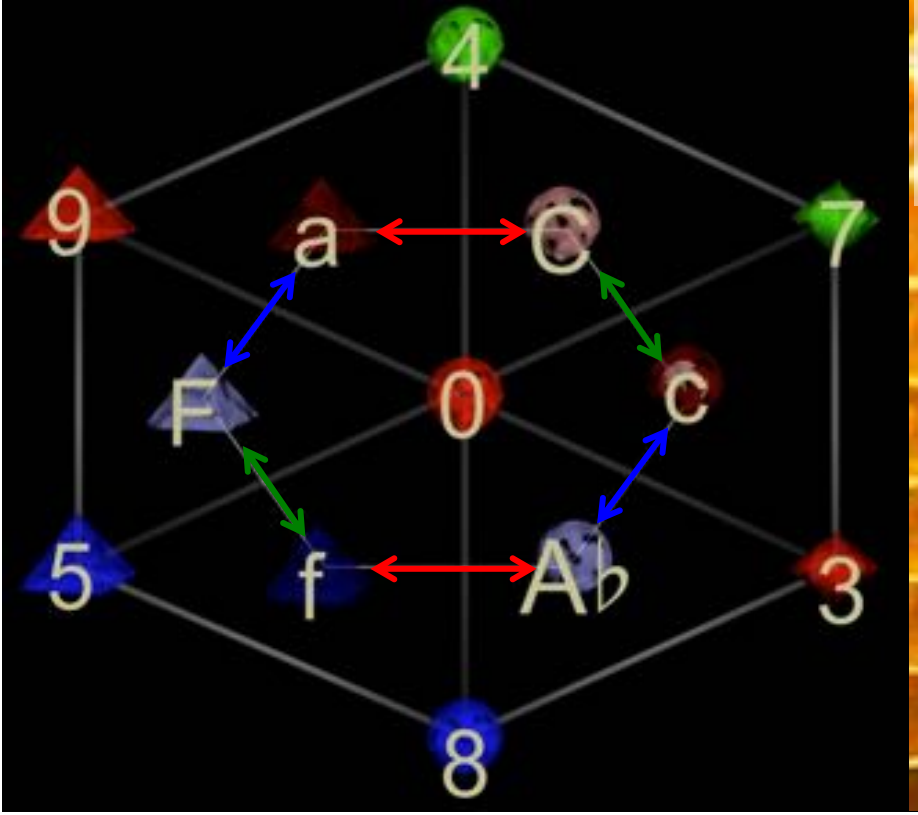
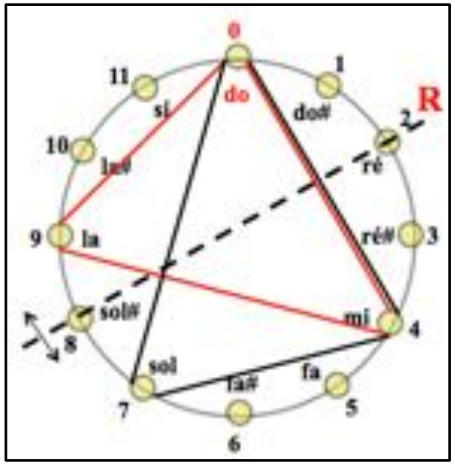
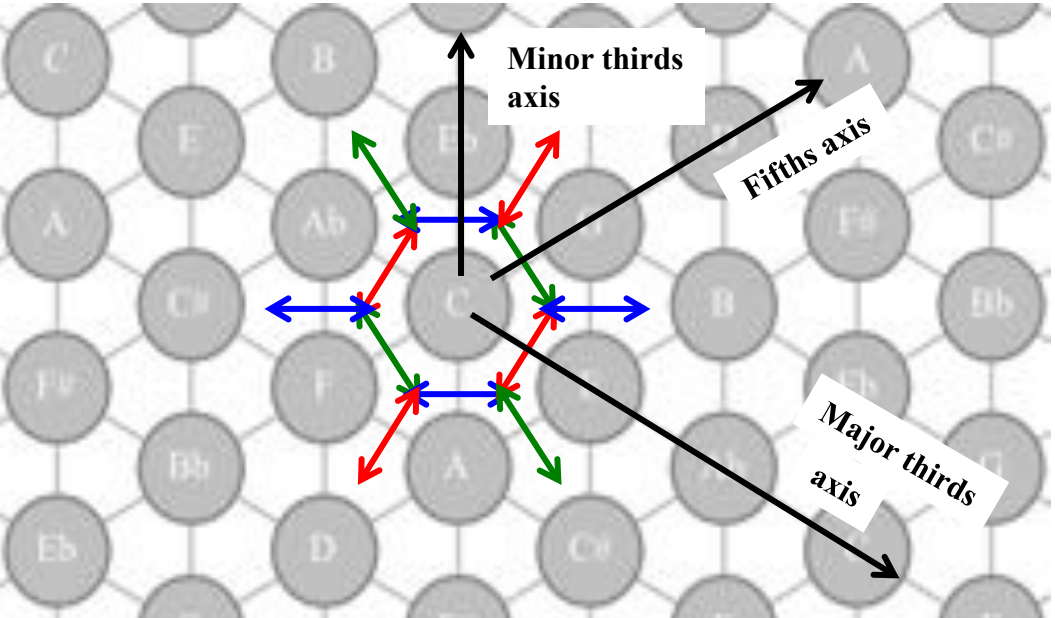
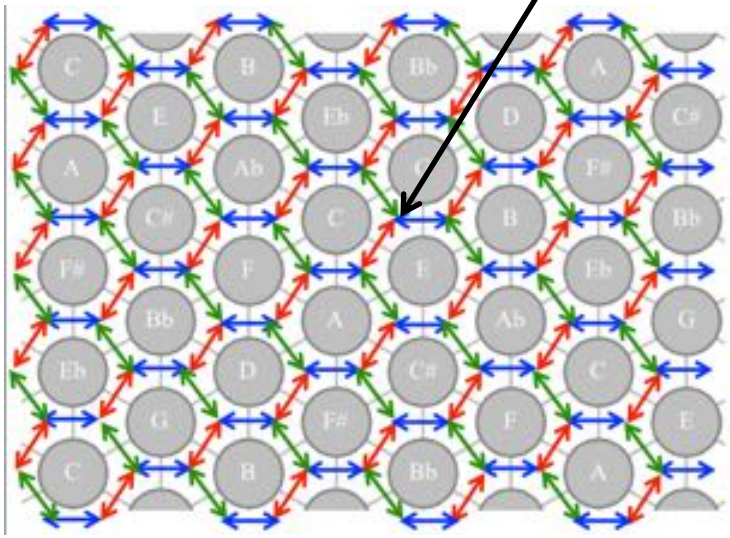
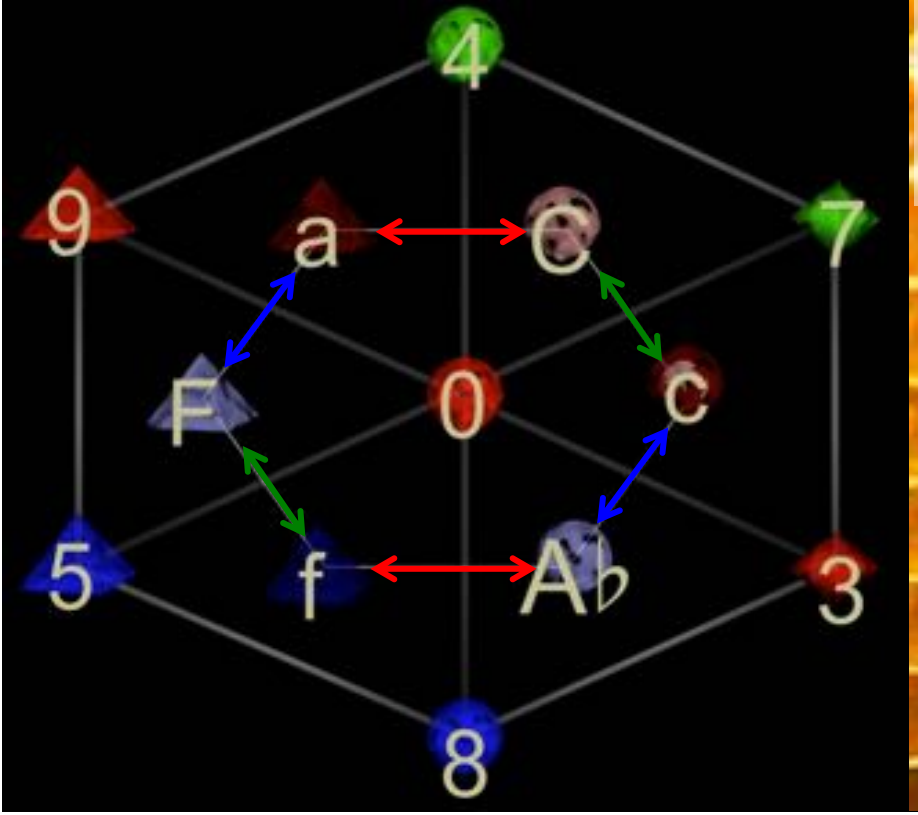


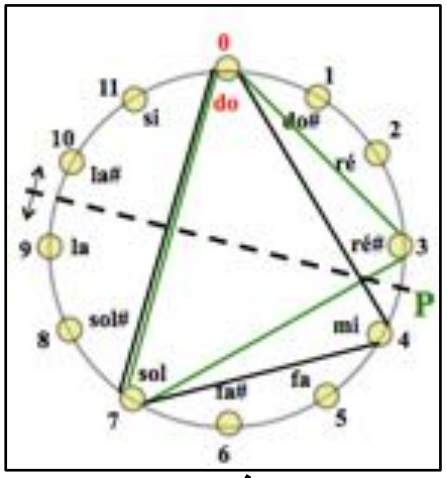


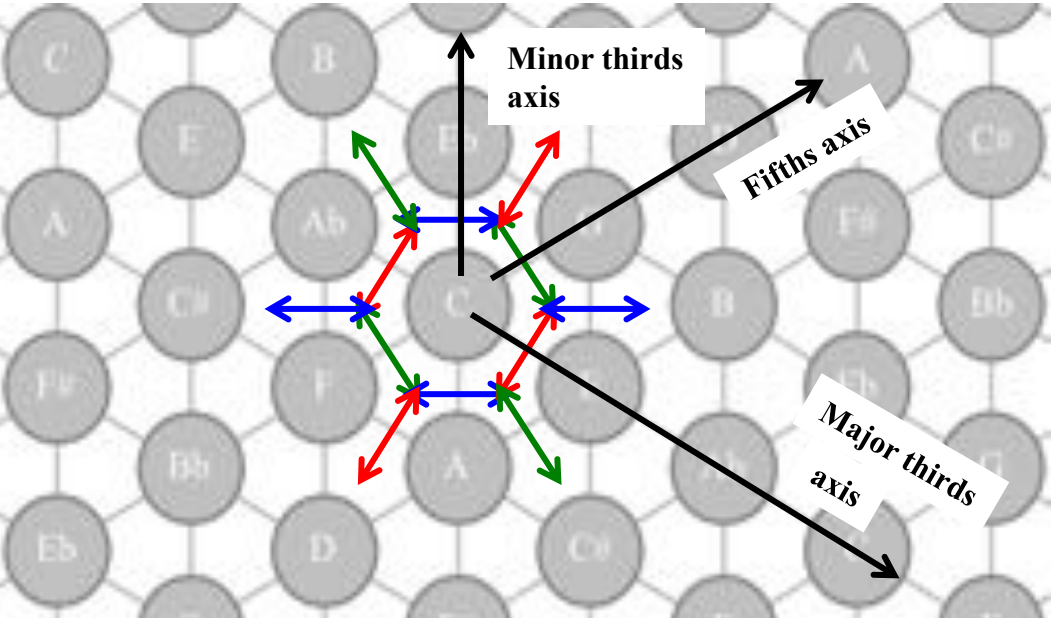


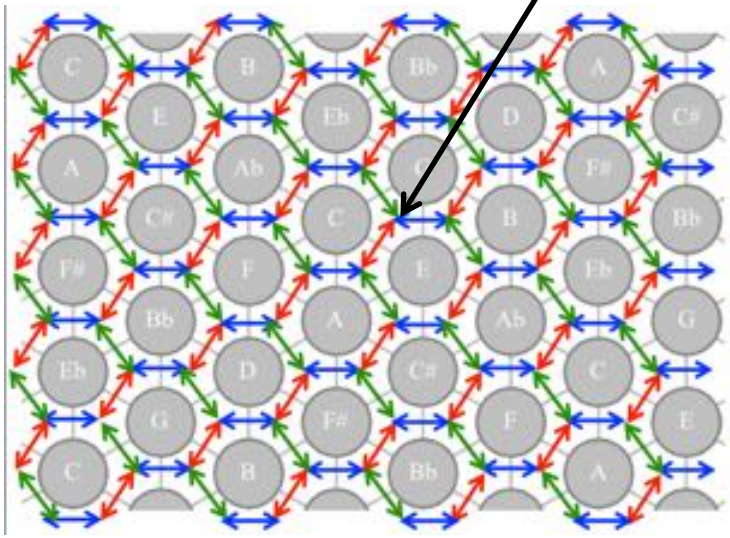


The *Tonnetz*
(or 'honeycomb' hexagonal tiling)

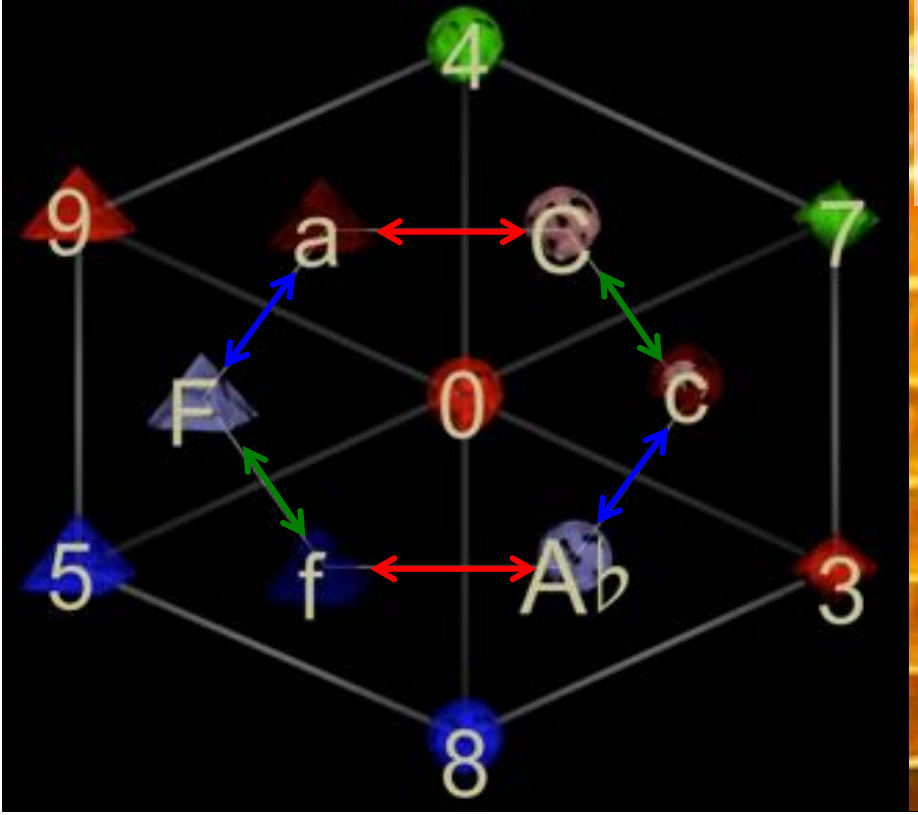


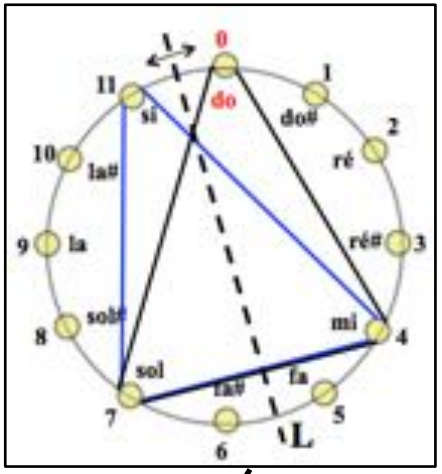


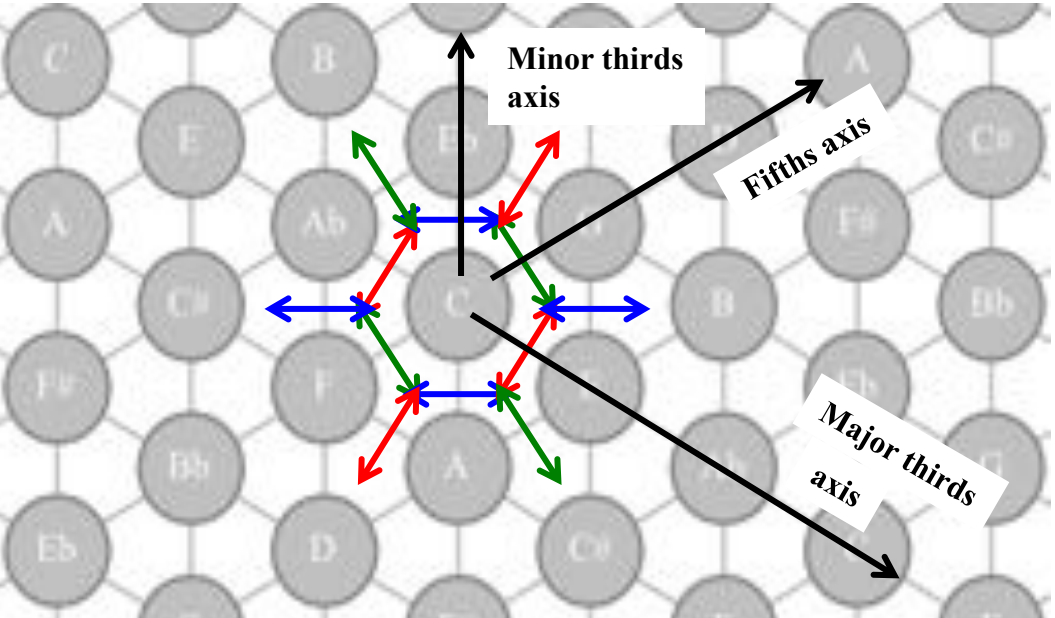


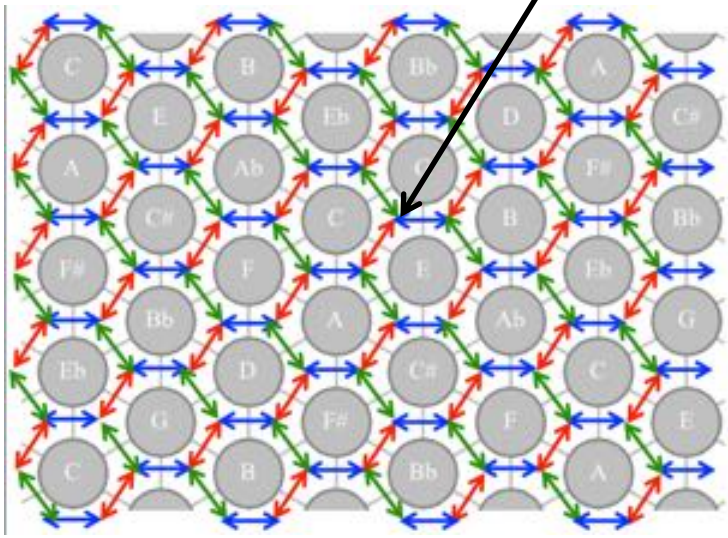


The *Tonnetz*
(or 'honeycomb' hexagonal tiling)

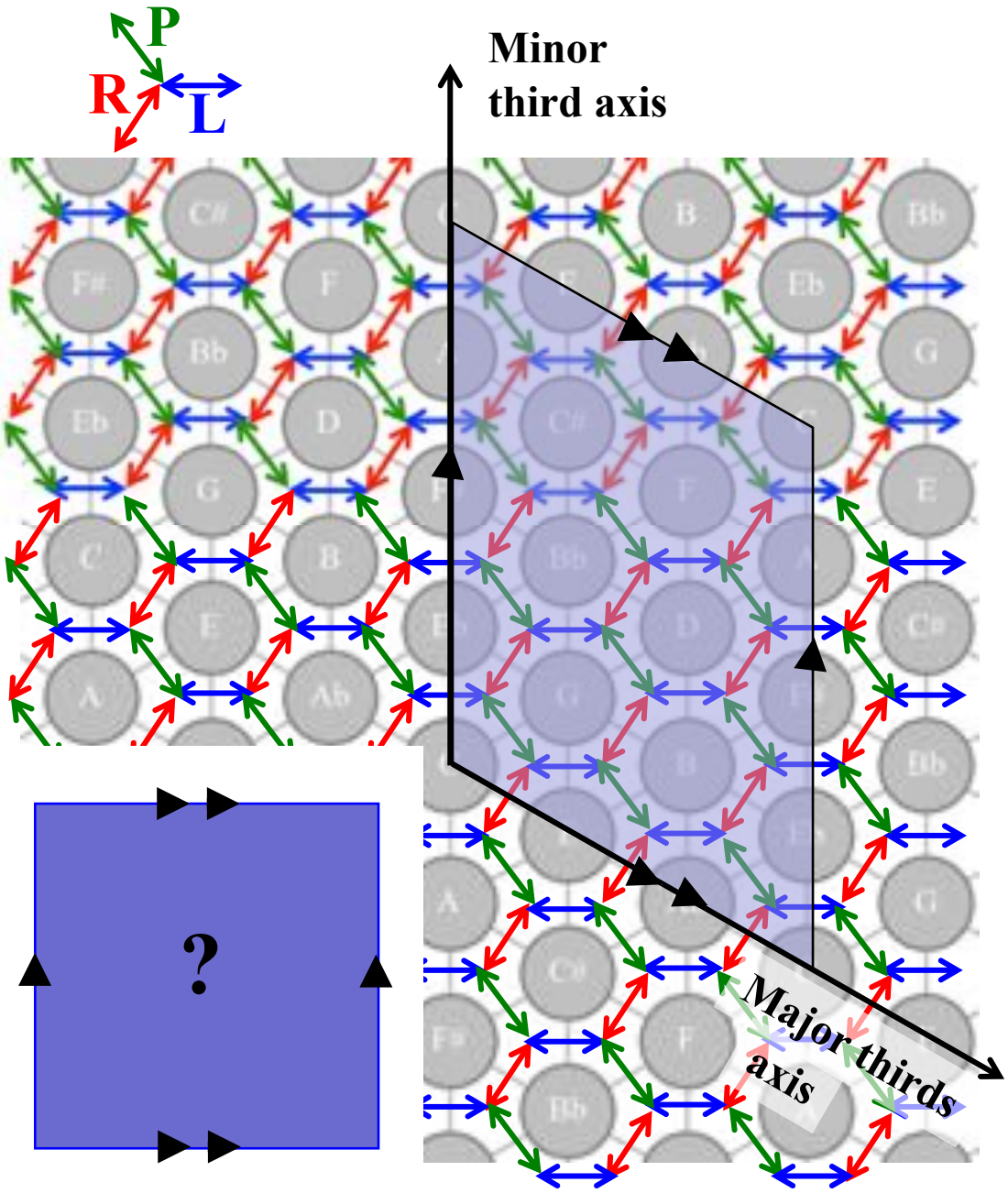


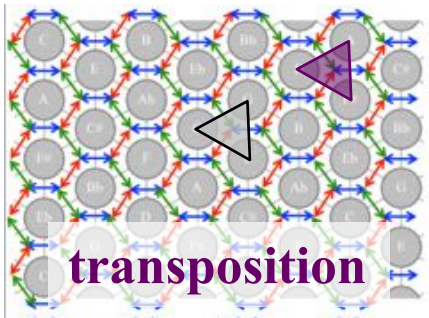


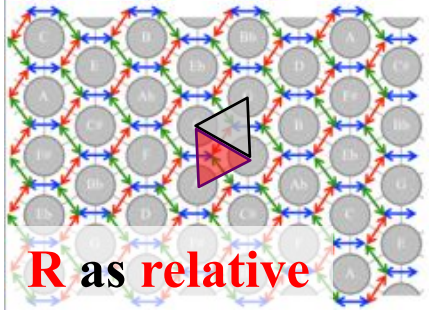


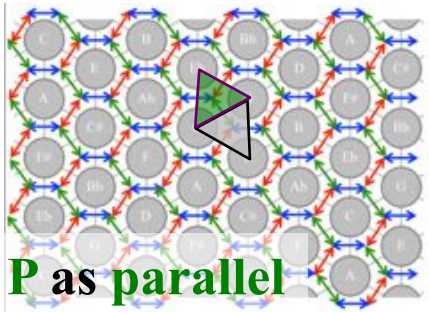


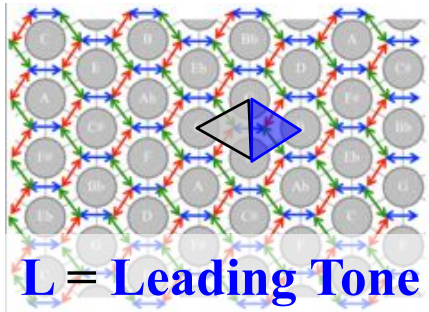
The *Tonnetz*, its symmetries and its topological structure

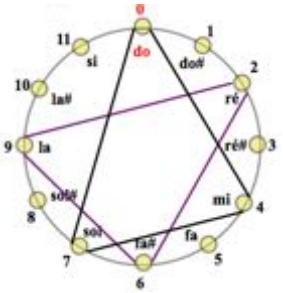


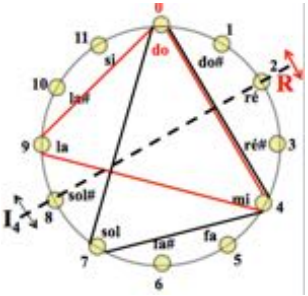


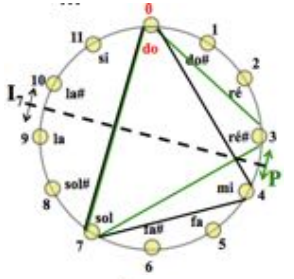


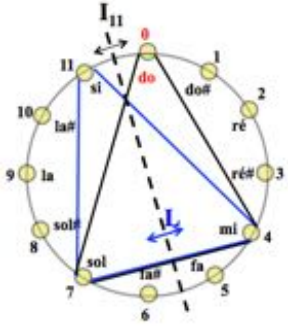




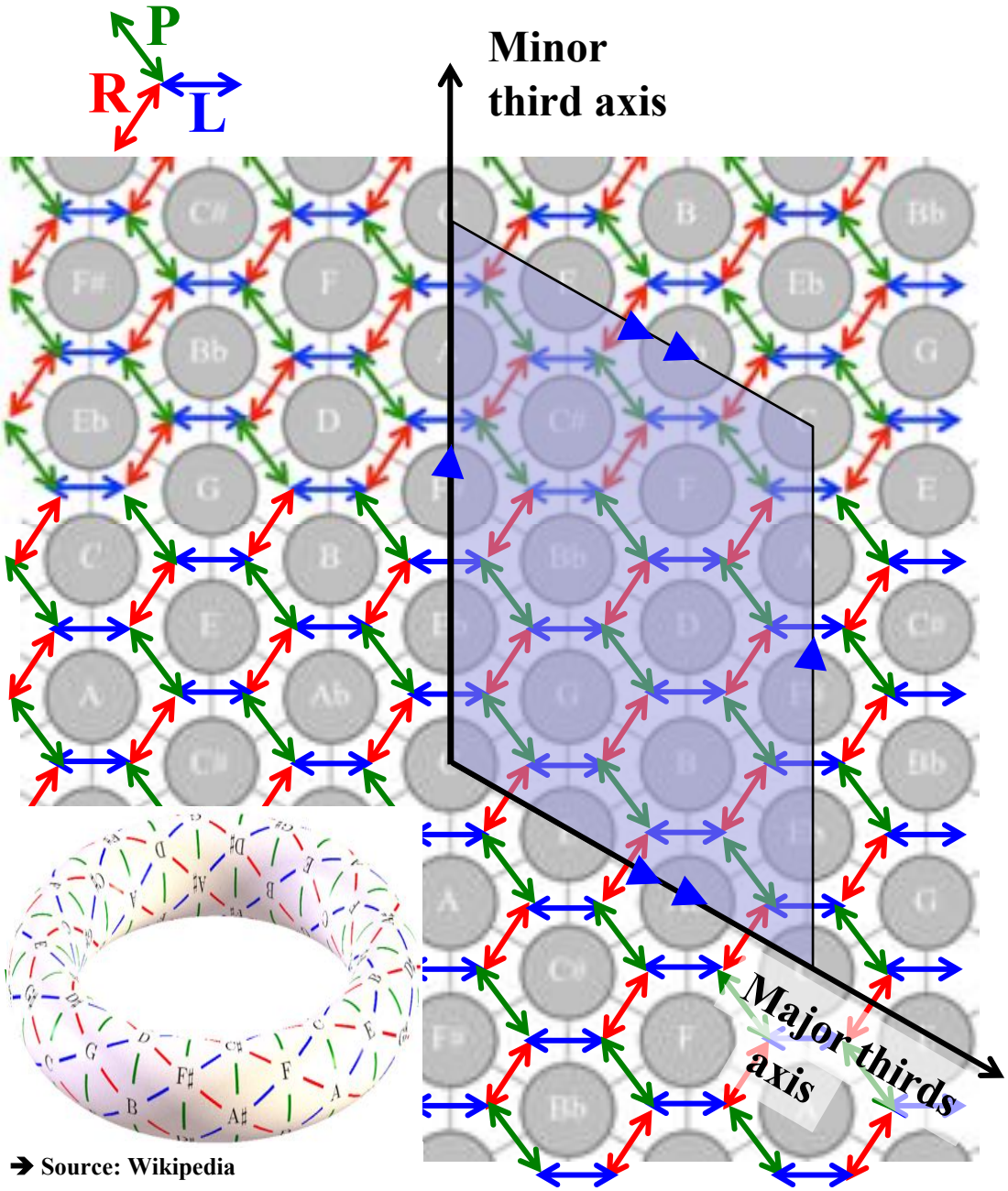




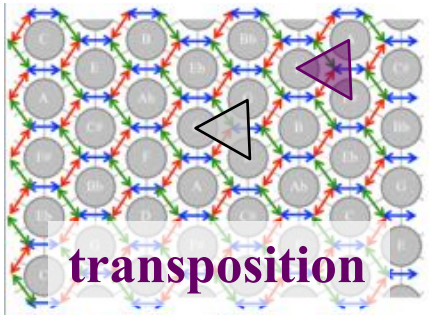


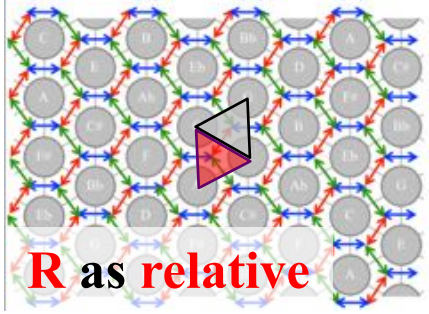


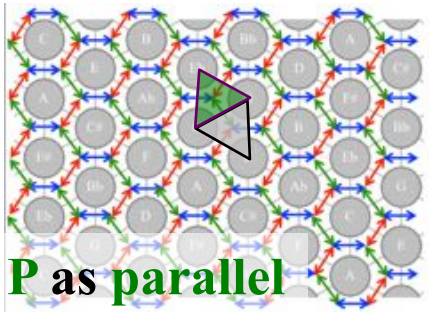
The *Tonnetz*, its symmetries and its topological structure

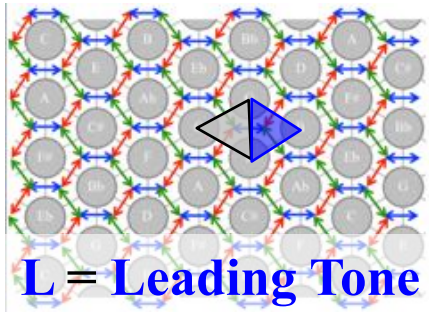


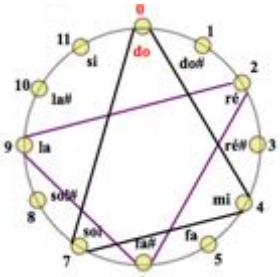
➔ Source: Wikipedia

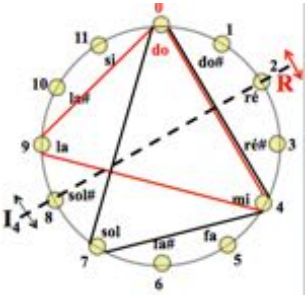


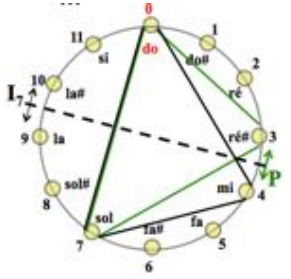


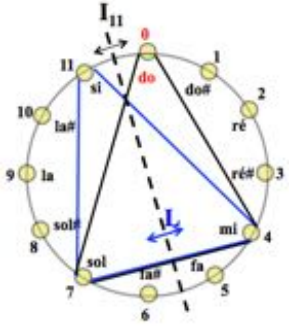




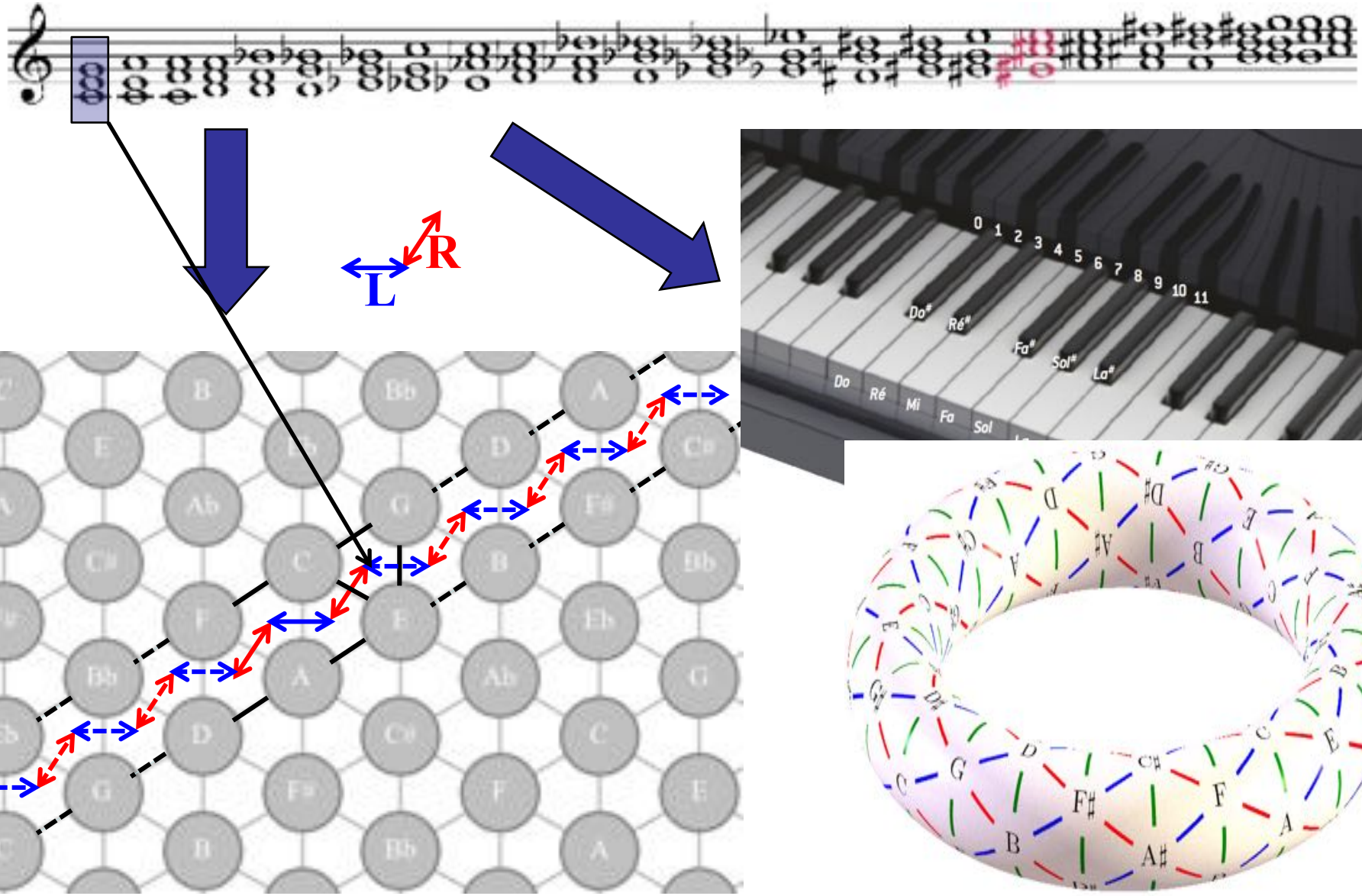








Harmonic progressions as spatial trajectories



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

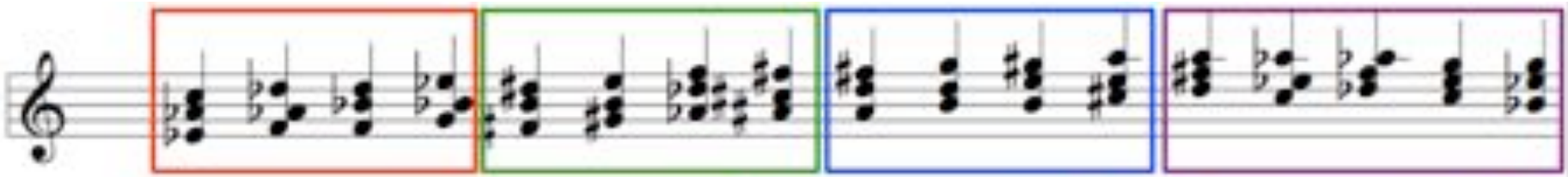
Beethoven and the Hypersphere

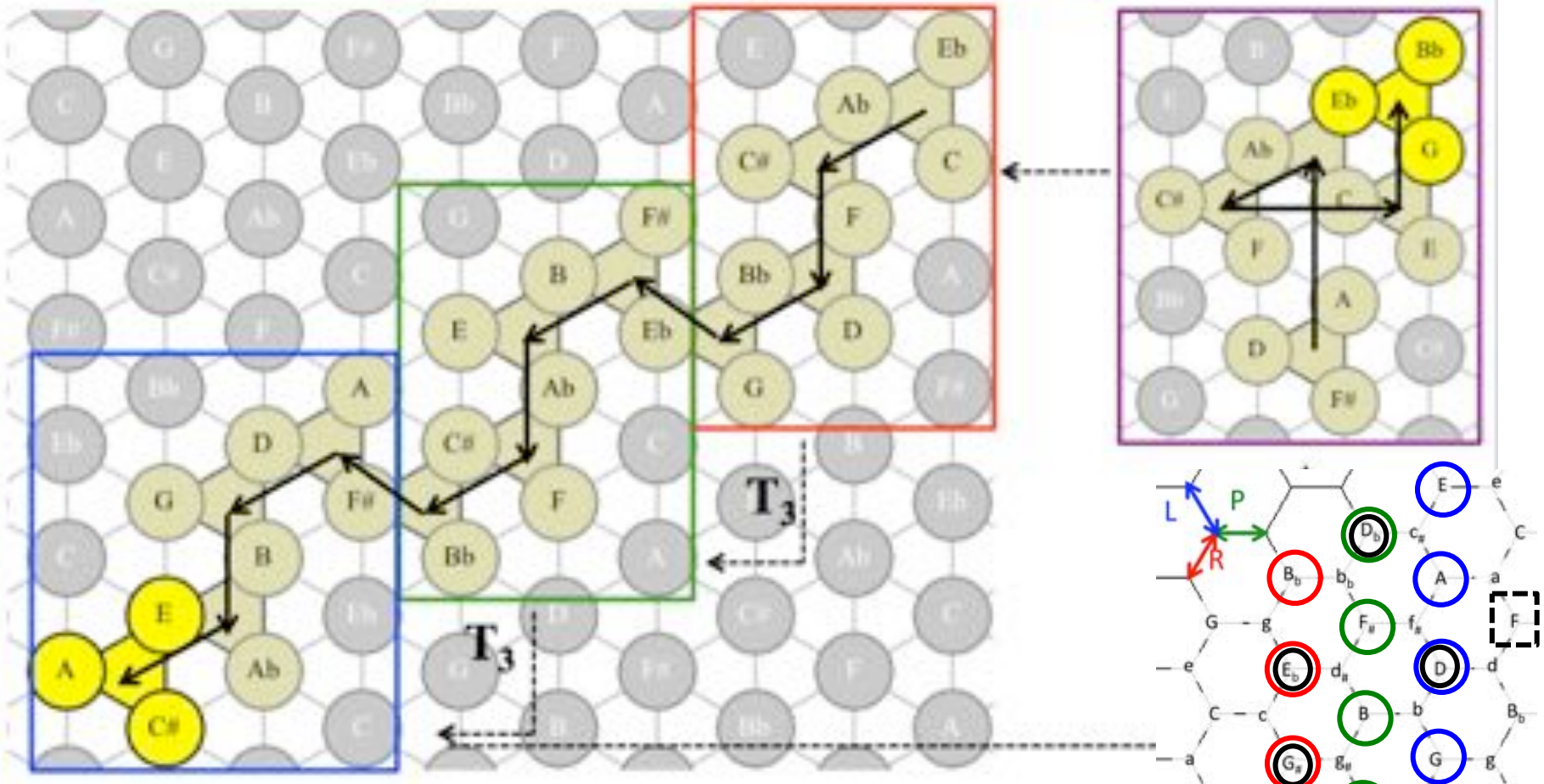
(and the Tonnetz)

Gilles Baroin 2016
www.MatheMusic.net

Symmetries in Paolo Conte's *Madeleine*

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



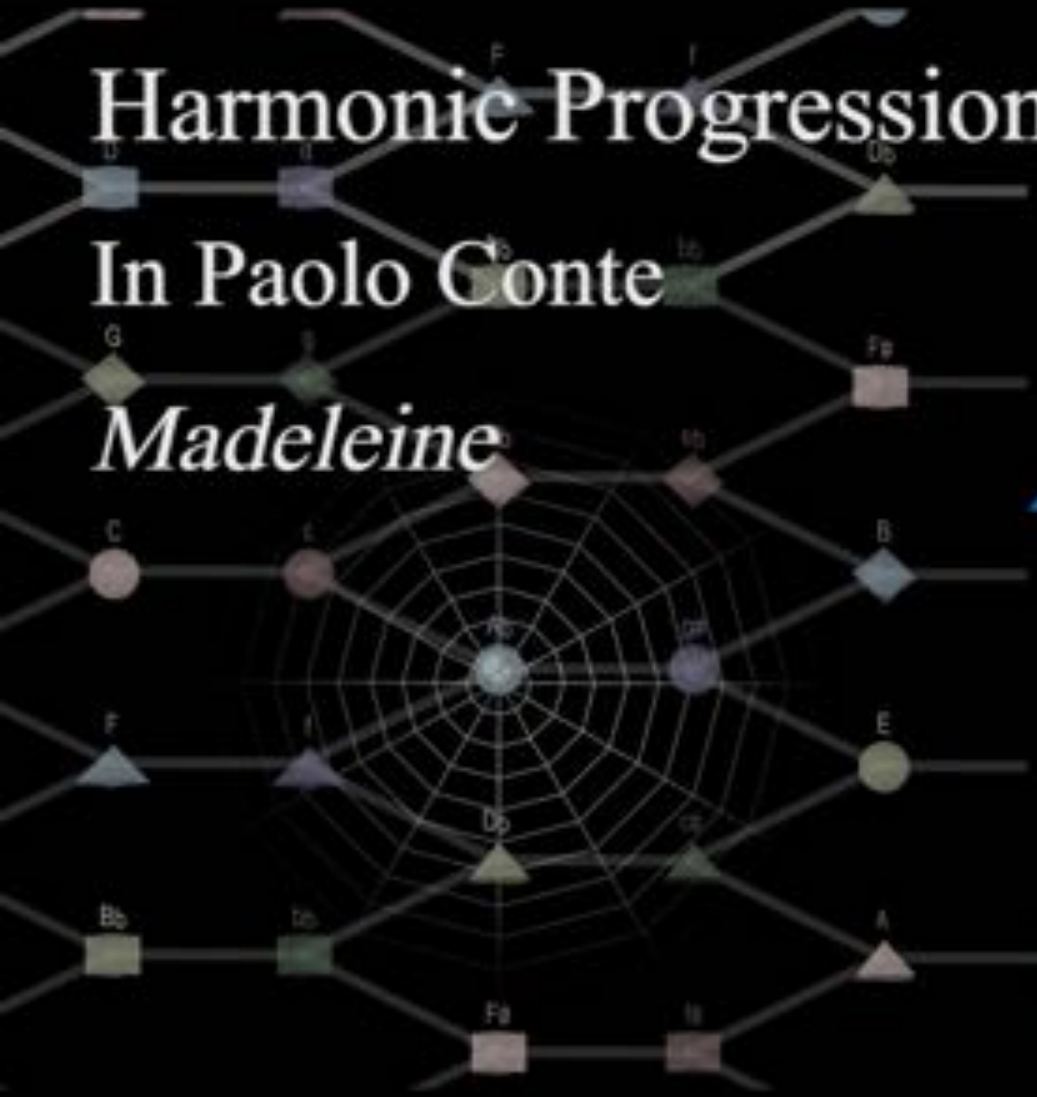


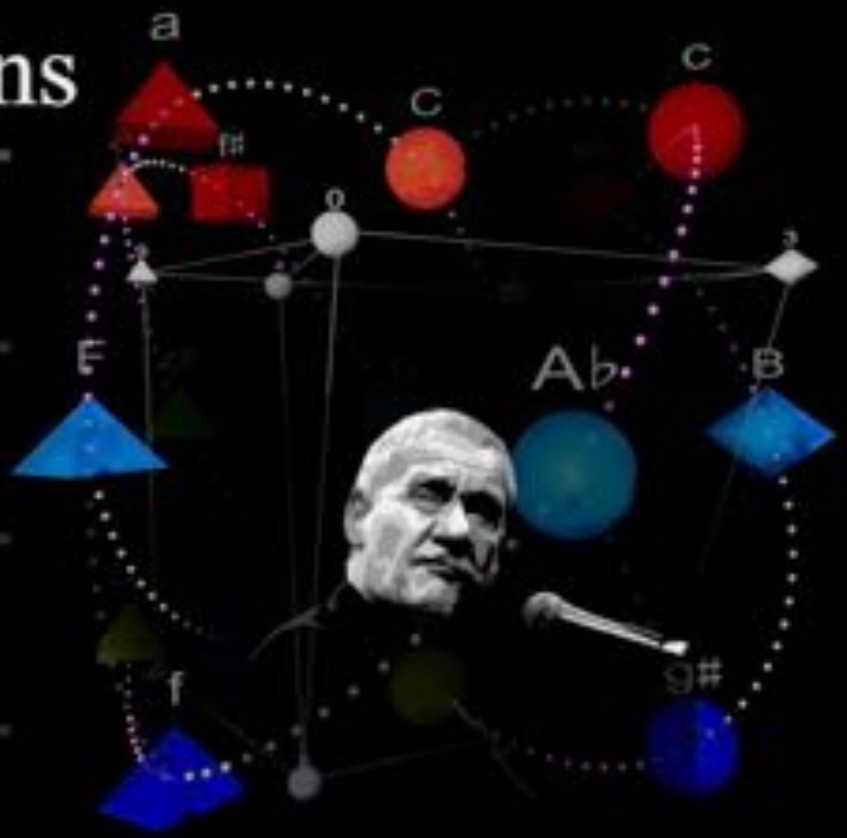
Almost total covering of the major-chords space

Harmonic Progressions

In Paolo Conte

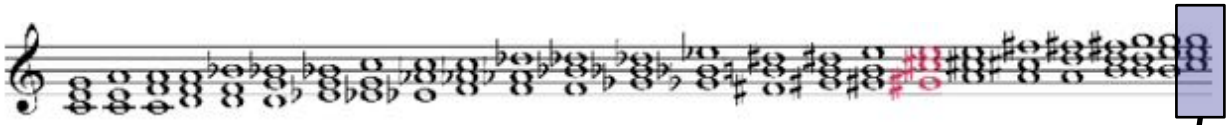
Madeleine





Supervision Moreno Andreatta
Modelisation Gilles Baroin 2016

Reading Beethoven backwards



time

Le Blé en Herbe

(Polo/Moreno/Dieu)

Plonger comme un enfant, cheveux au vent
Sous l'océan du blé en herbe
Marée d'épis couleur d'amande
Qui tendent à caresser le ciel

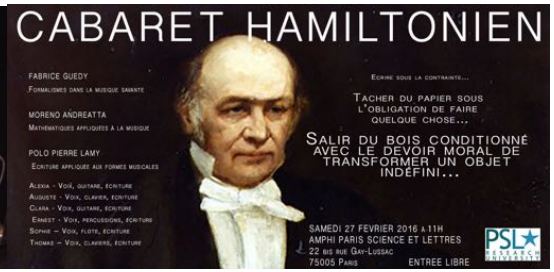
Algues tendres de mille plages
Frôlant le ventre des nuages
Cheveux de pluie, dos de poissons
Qui frissonnent à l'unisson

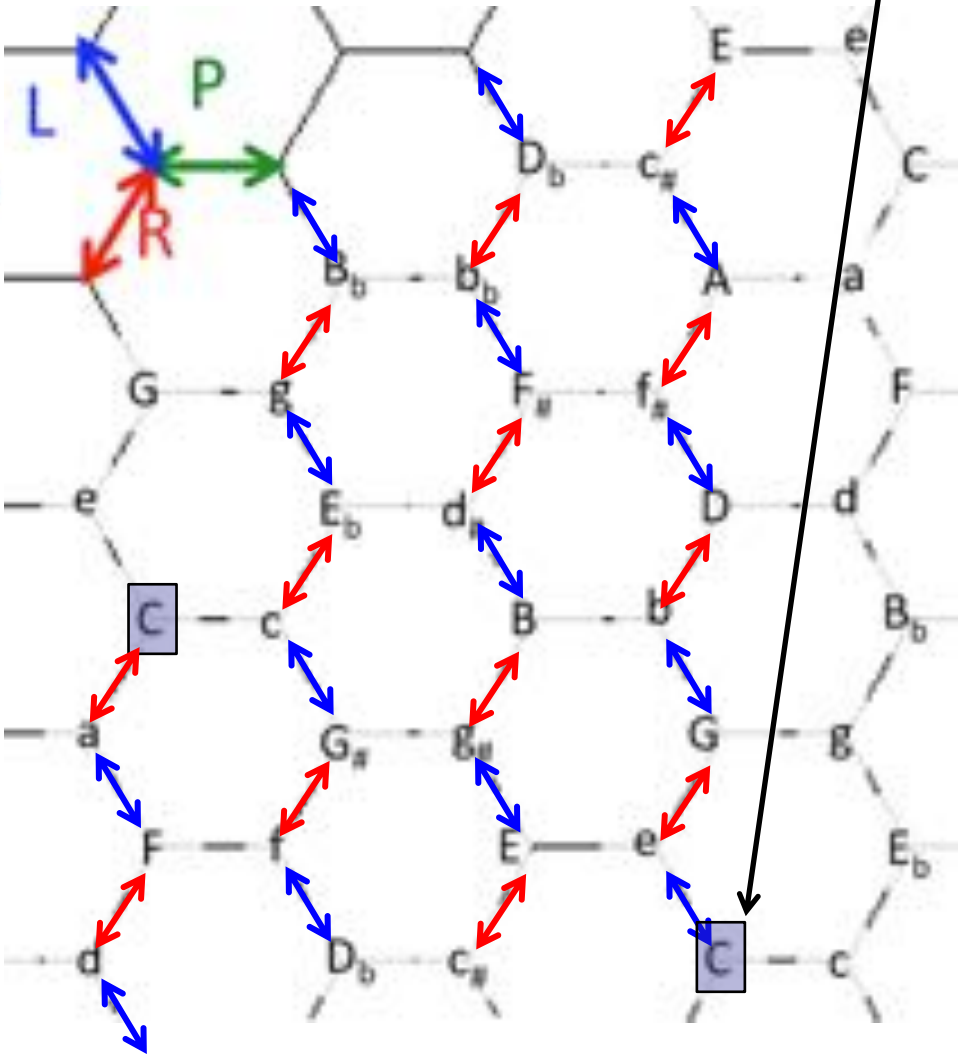
Suivre le bord des continents
Dans l'océan du blé en herbe
Pêcher le corail du pavot
Dans le sang des coquelicots

Croiser matin dans l'herbe folle
Deux tourterelles qui s'envolent
Suivre les jeux des hirondelles
Sur le paysage éternel
Nager comme un enfant, cheveux au vent
Sous l'océan
Du blé en herbe

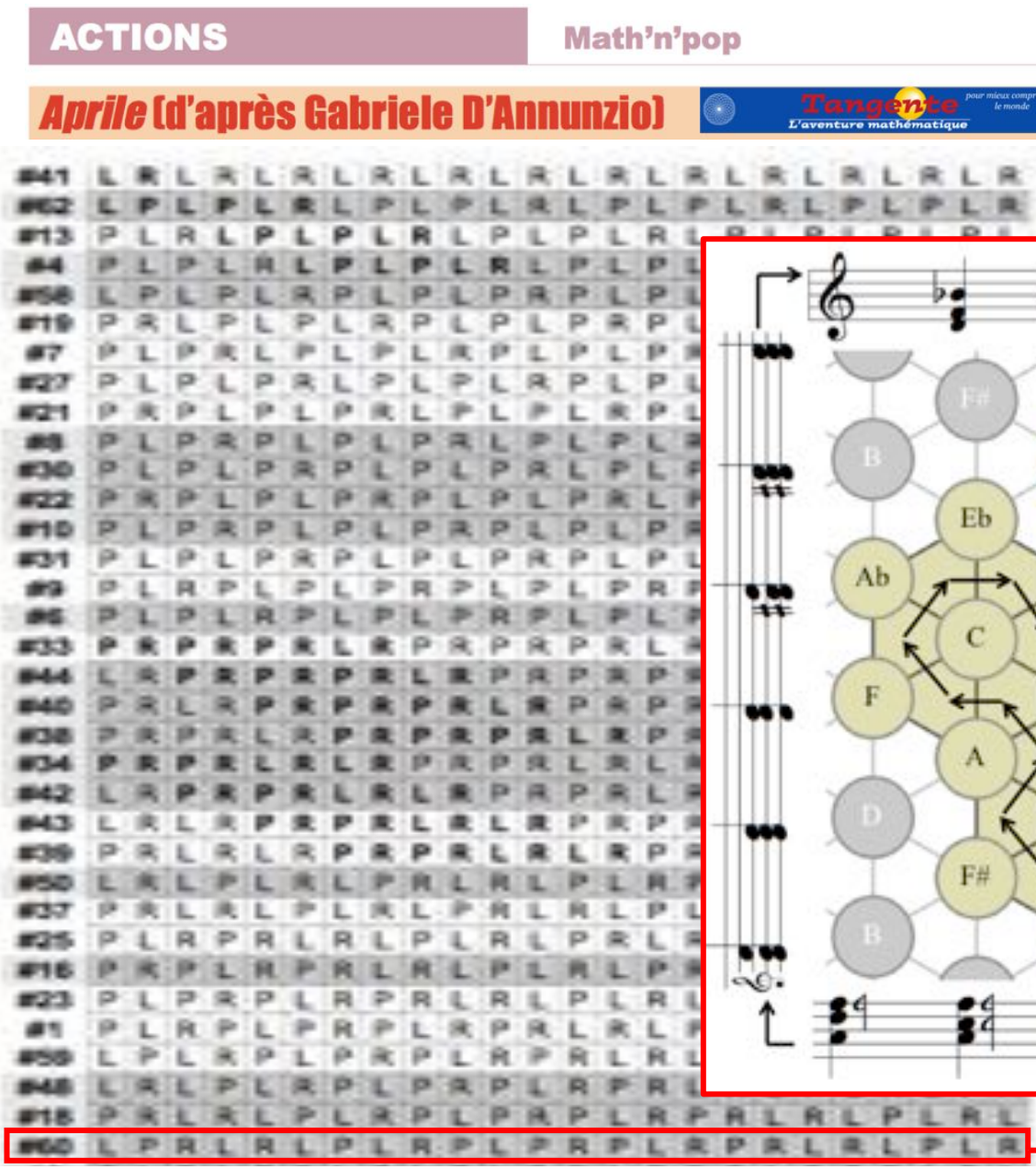
Marée de fruits au goût amer
Acide et salée comme la mer

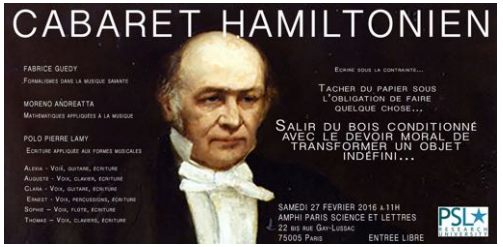
Vers l'îlôt d'un petit village
Vers un château d'eau sur la plage
Quand tout s'éteint avant l'orage
Quand se lève le vent du large
Sur le blé vert

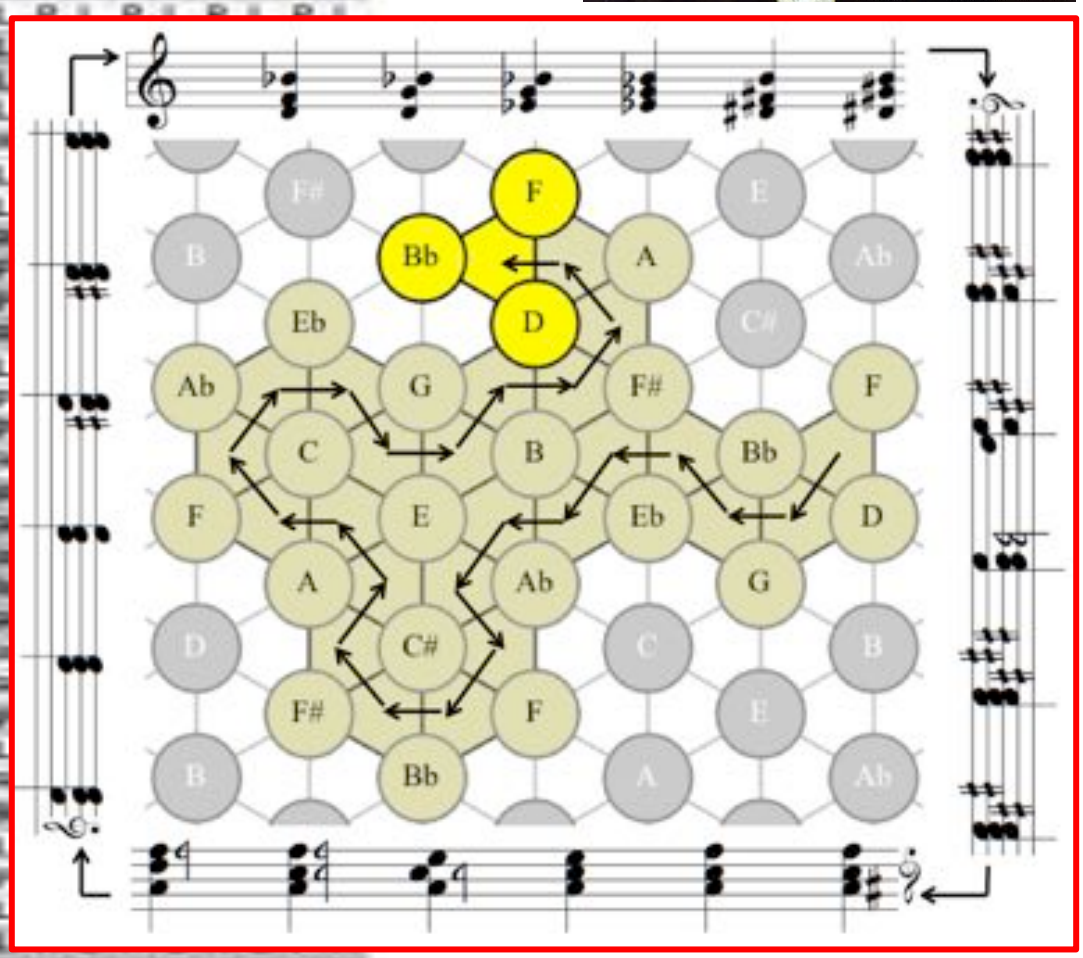




The collection of 124 Hamiltonian Cycles







G. Albini & S. Antonini, University of Pavia, 2008

Aprile, a Hamiltonian « decadent » song

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

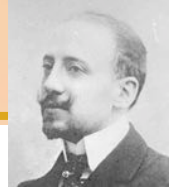
↘ La ↗ ↗

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

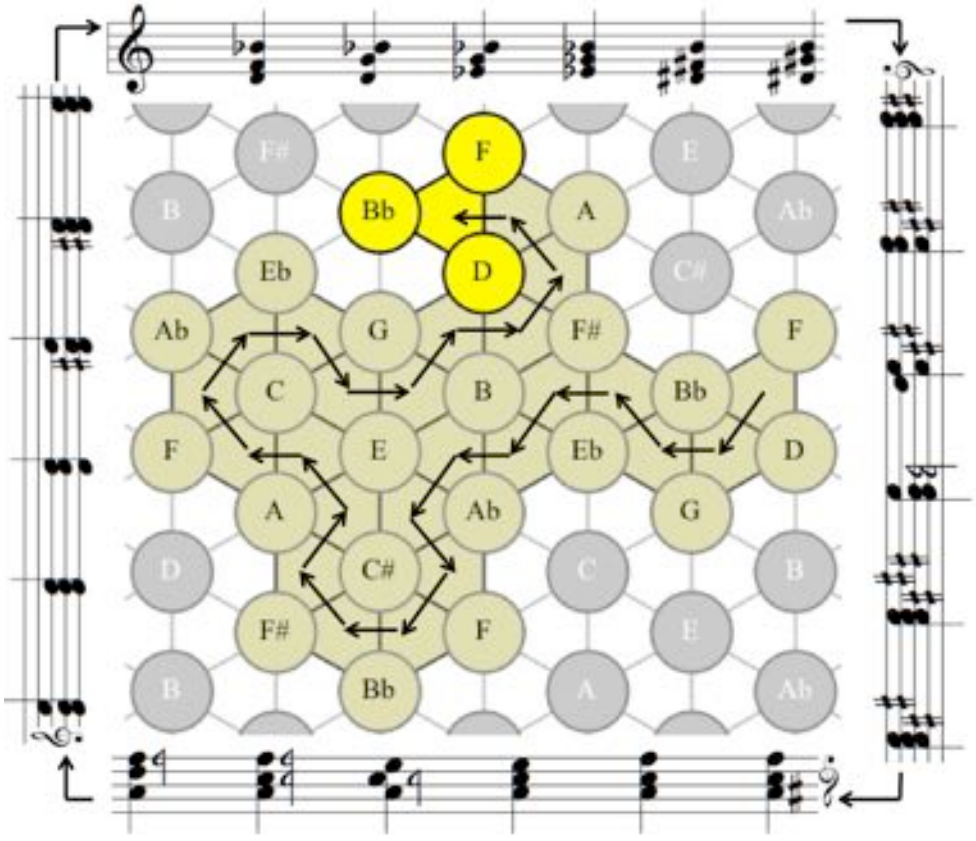
Socchiusa è la finestra, sul giardino.
Un'ora passa lenta, sonnolenta.
Ed ella, ch'era attenta, s'addormenta
A quella voce che già si lamenta,
Che si lamenta in fondo a quel giardino.

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

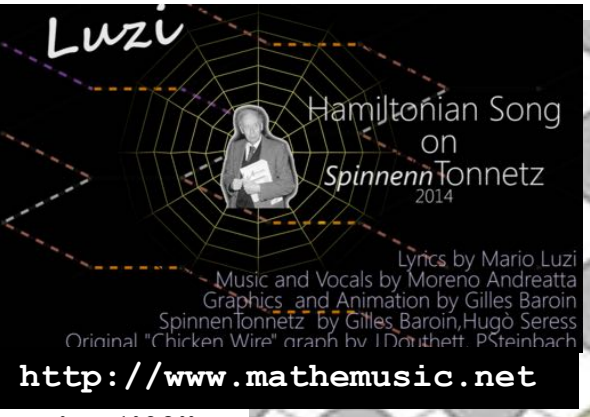
Aprile (d'après Gabriele D'Annunzio)

Tangente pour mieux comprendre le monde L'aventure mathématique

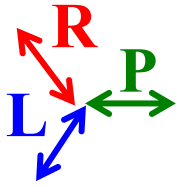
Hamiltonian Cycles with inner periodicities

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.

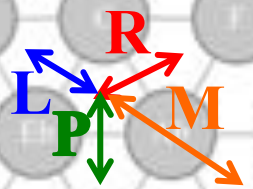
Caduto è più che un segno della vita,
riposi, dal viaggio sei tornata
dentro di te, sei scesa in questa pura
sostanza così tua, così romita
nel silenzio dell’essere, (compiuta).

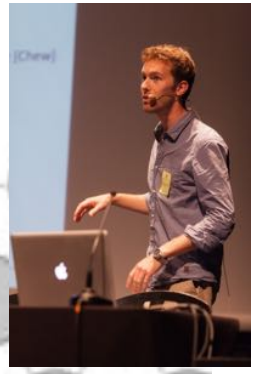
L’aria tace ed il tempo dietro a te
si leva come un’arida montagna
dove vaga il tuo spirito e si perde,
un vento raro scivola e ristagna.


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

Symmetries and algorithmic processes in *Muse*

"Take a bow" (*Black Holes and Revelations*, 2006)





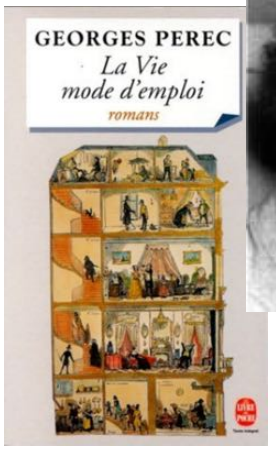
Louis Bigo

Hexachord (Louis Bigo, 2013)

Temporal axis

The use of constraints in arts

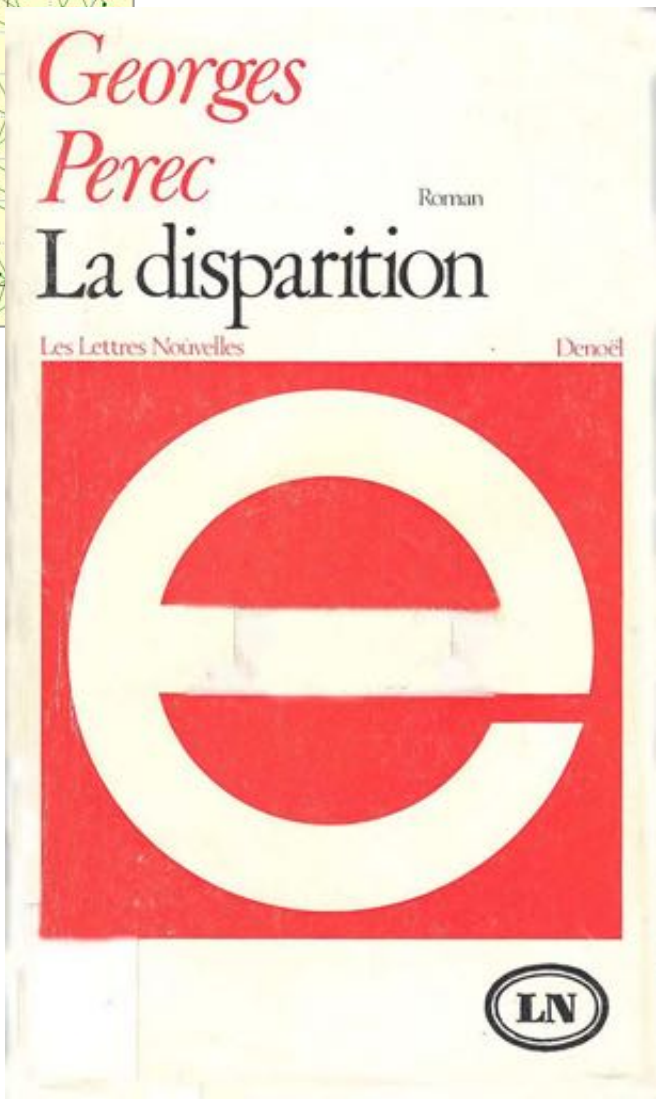
Cent mille milliards de poèmes, 1961



Georges Perrec

La vie mode d'emploi,

OuLiPo (Ouvroir de Littérature Potentielle)



Raymond Queneau

Italo Calvino

Il castello dei destini incrociati, 1969

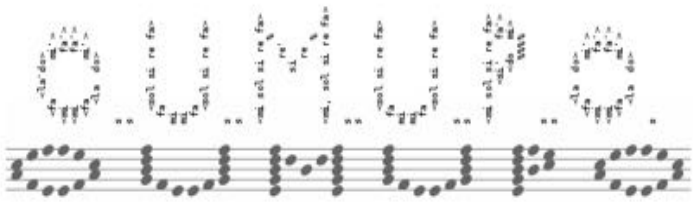
From the OuLiPo to the OuMuPo (ouvroir de musique potentielle)

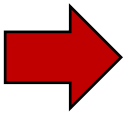
Cent mille milliards de poèmes, 1961

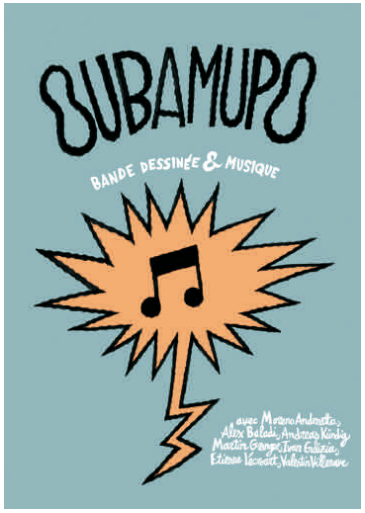
La vie mode d'emploi,

Raymond Queneau

Italo Calvino
Le Château des destins croisés, 1969







Valentin Villenave

Mike Solomon

Jean-François Piette

Martin Granger

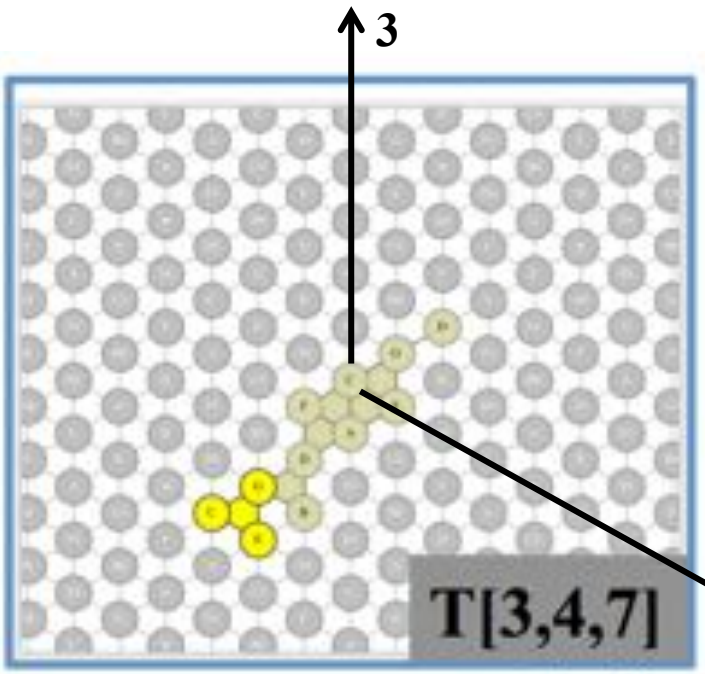
Joseph Boisseau

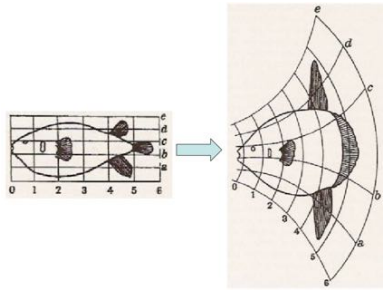
Moreno Andreatta

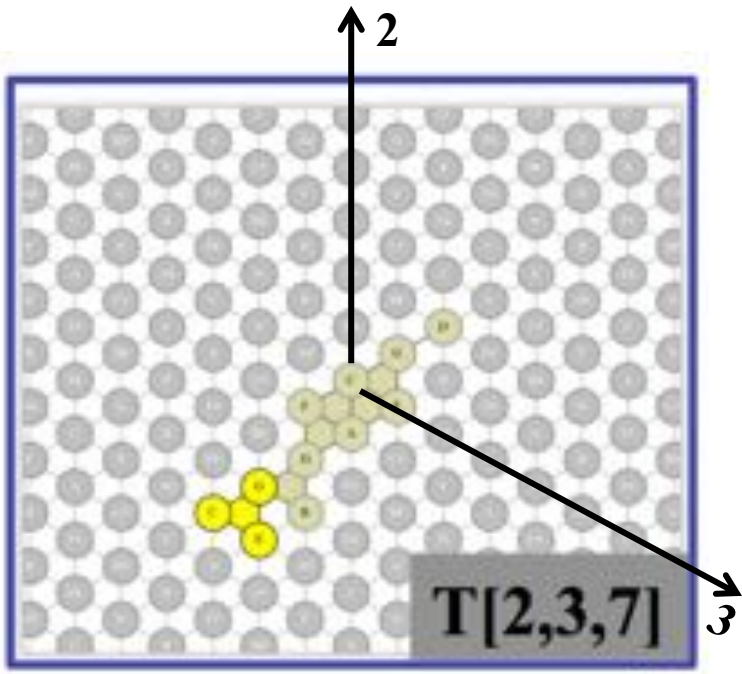
Tom Johnson

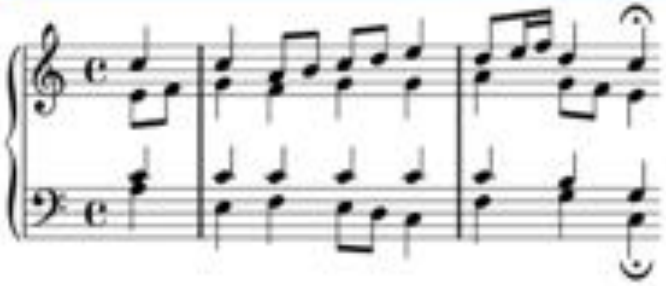
http://oumupo.org/

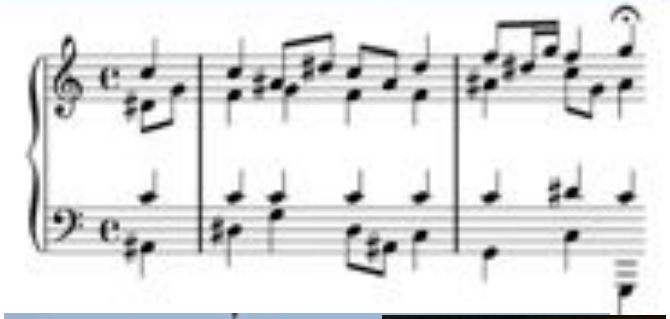
The musical style...is the space!



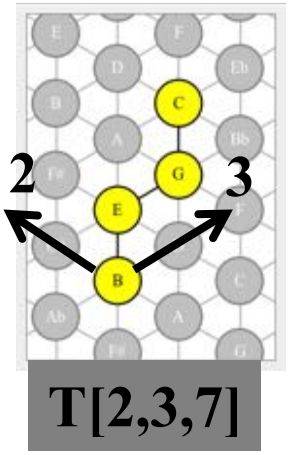


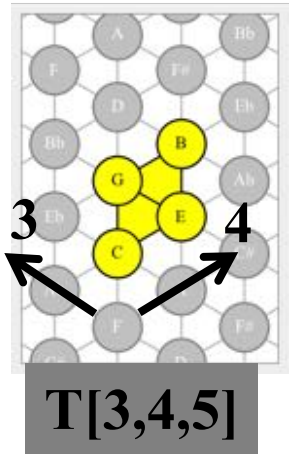


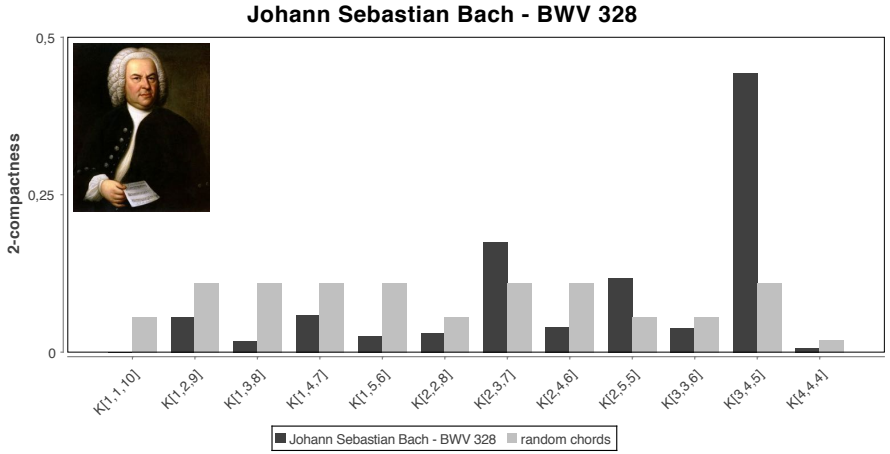


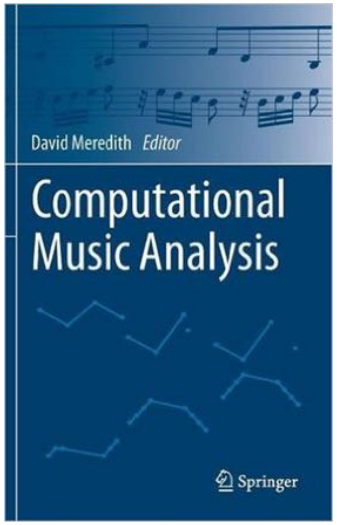


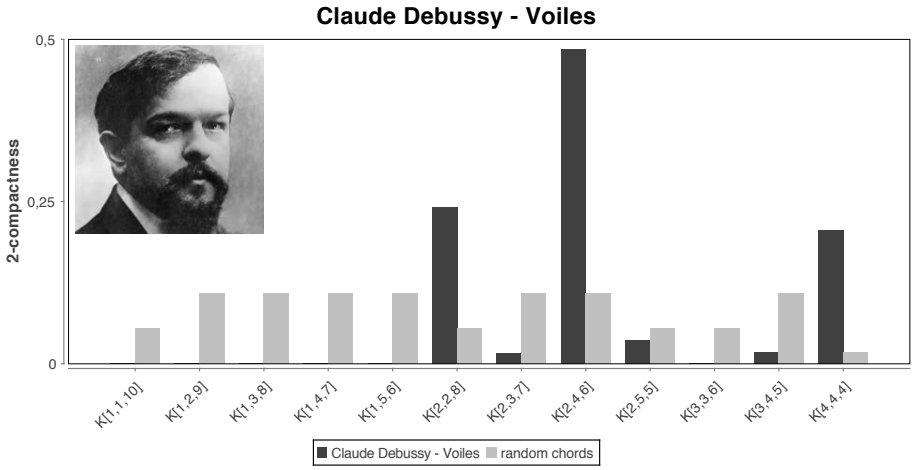
The geometric character of musical logic

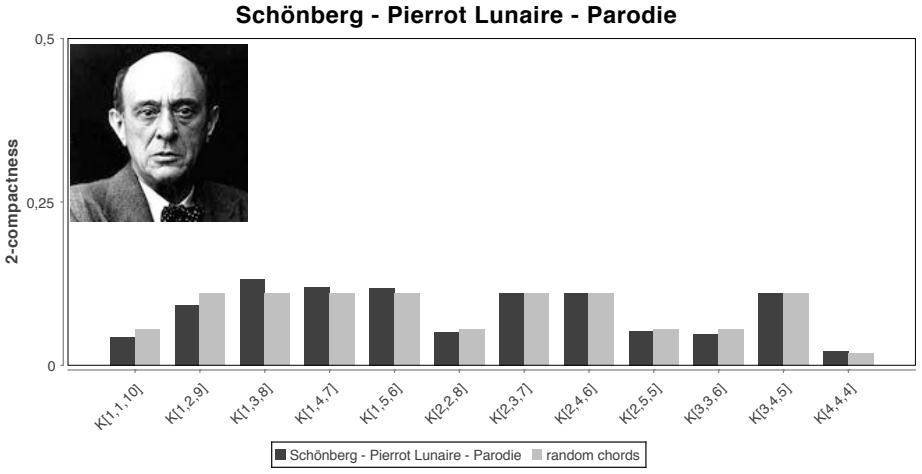




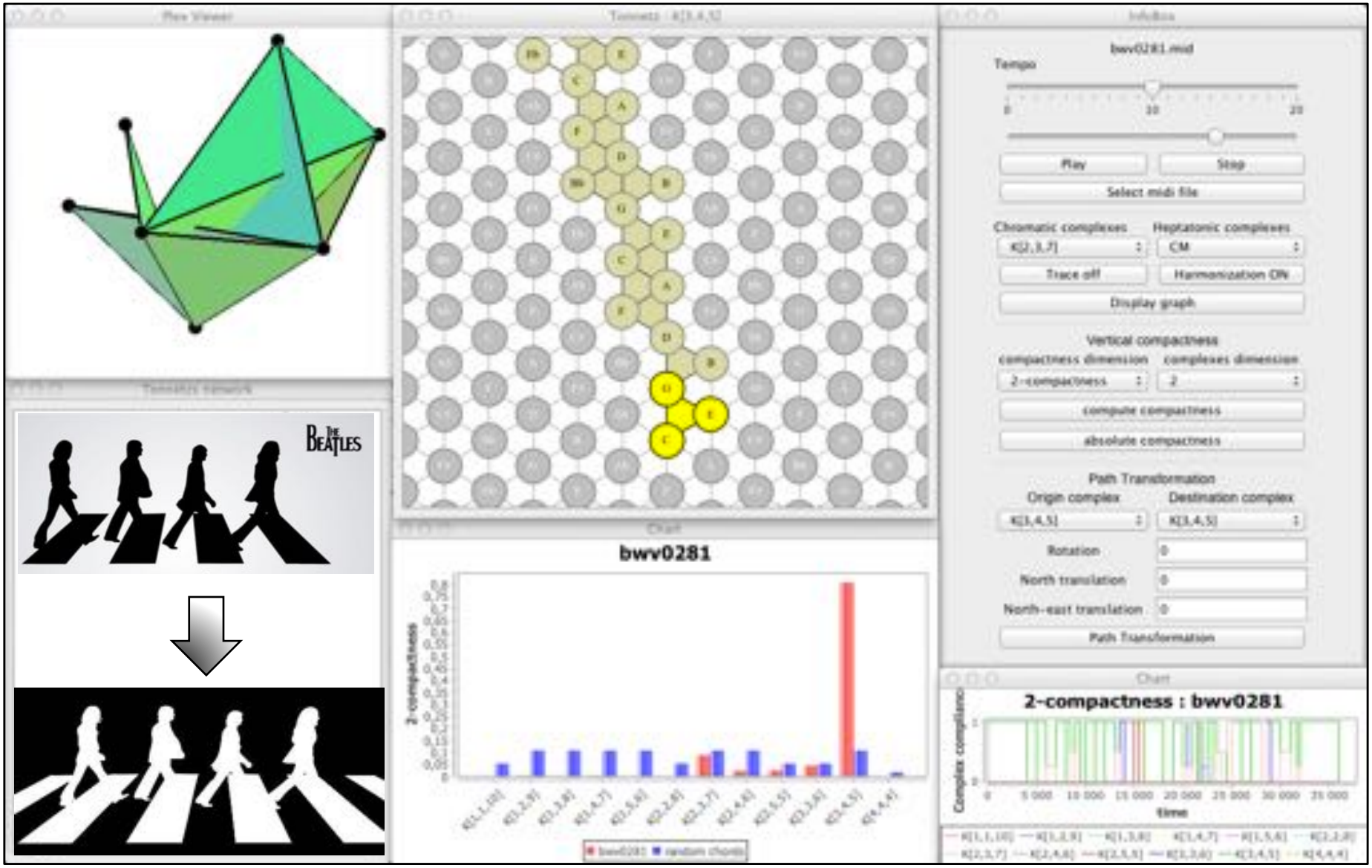








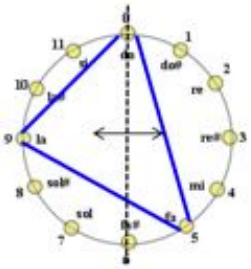
Keeping the space...but changing the trajectory!



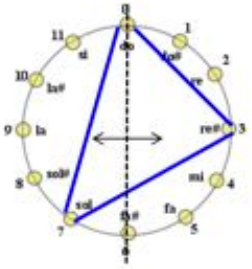
➔http://www.lacl.fr/~lbigo/hexachord

Keeping the space...but changing the trajectory!

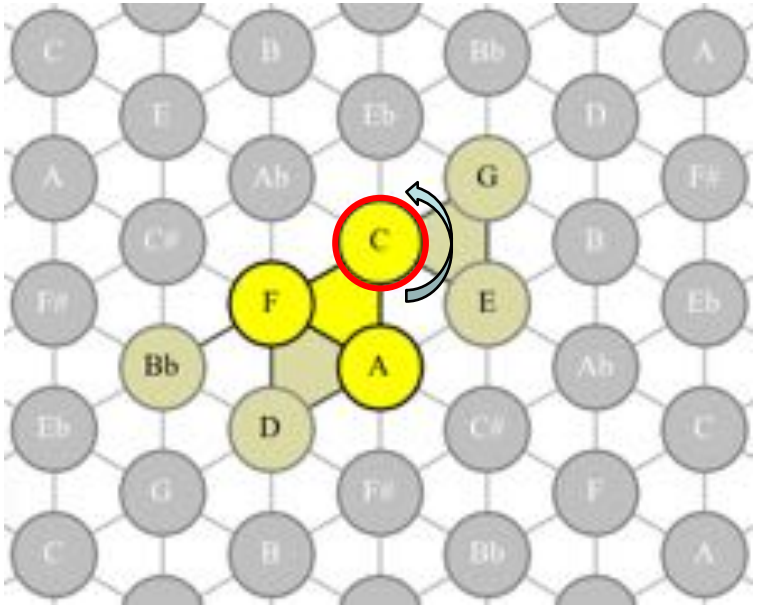
F major chord



inversion

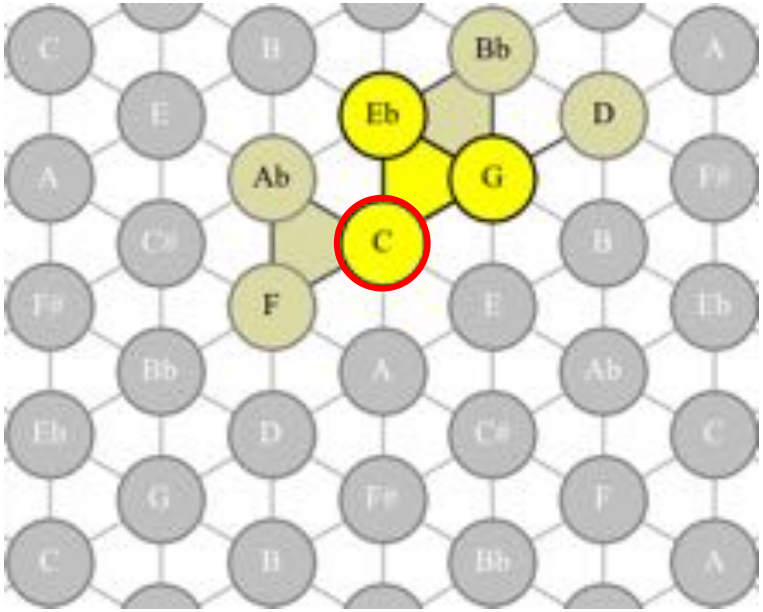


C minor chord



Beatles, Hey Jude (orig. version)

Rotation
(autour du *do*)



Beatles, Hey Jude (transformed version)


Thank you for your attention!