

Atelier d'initiation aux rapports mathématique/musique



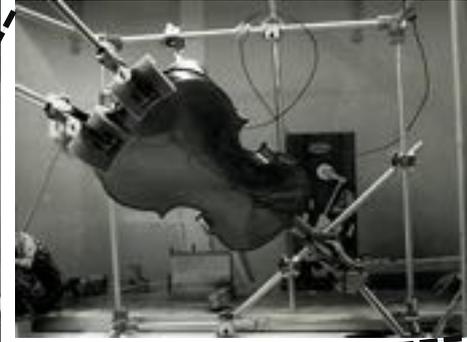
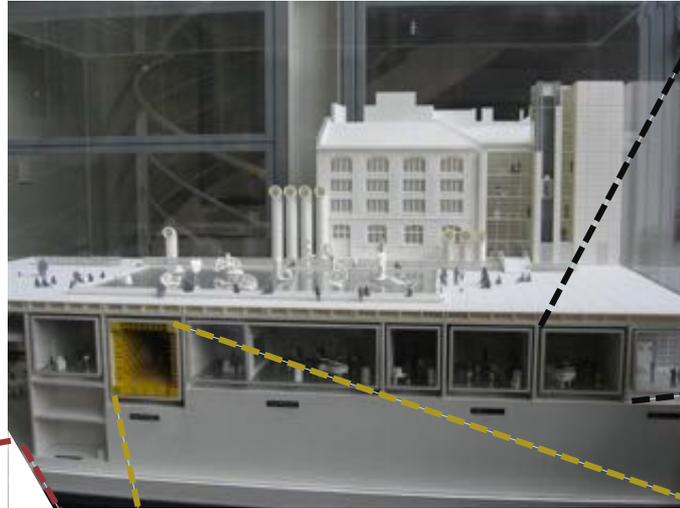
Moreno Andreatta

IRMA & GREAM, Université de Strasbourg

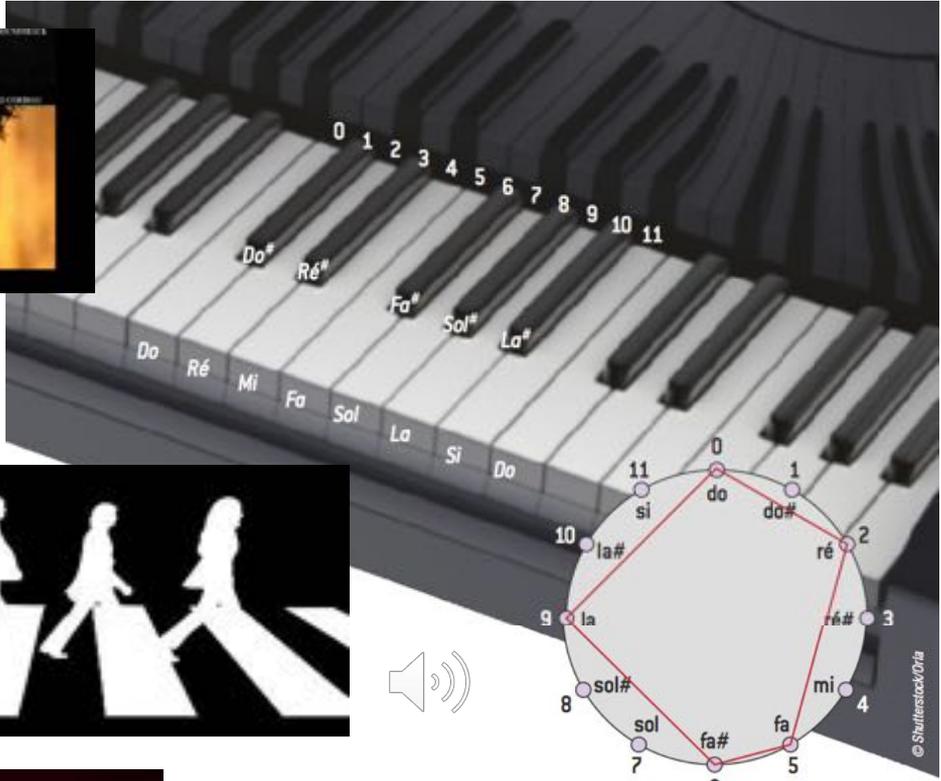
IRCAM / CNRS UMR 9912 / Sorbonne Université

Equipe Représentations Musicales

La recherche musicale et scientifique à l'IRCAM...



... entre musique savante et *popular music*



MusiqueLab 2



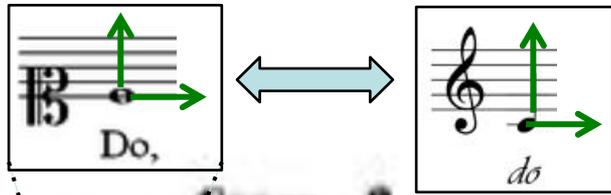
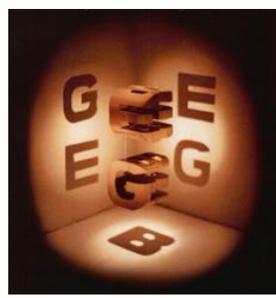
OMAX (computer-aided impro)



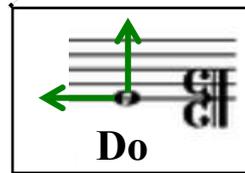
Pythagore et le monocorde



Canons énigmatiques chez Bach et géométrie



Canones diversi
super thema regium



Ma fin est mon début (mais renversé !)

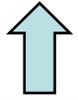
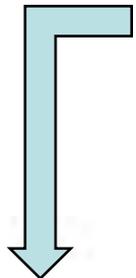


Canones diversi super thema regium:

1. Canon a 2

Canones diversi super thema regium:

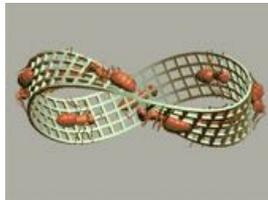
1. Canon a 2



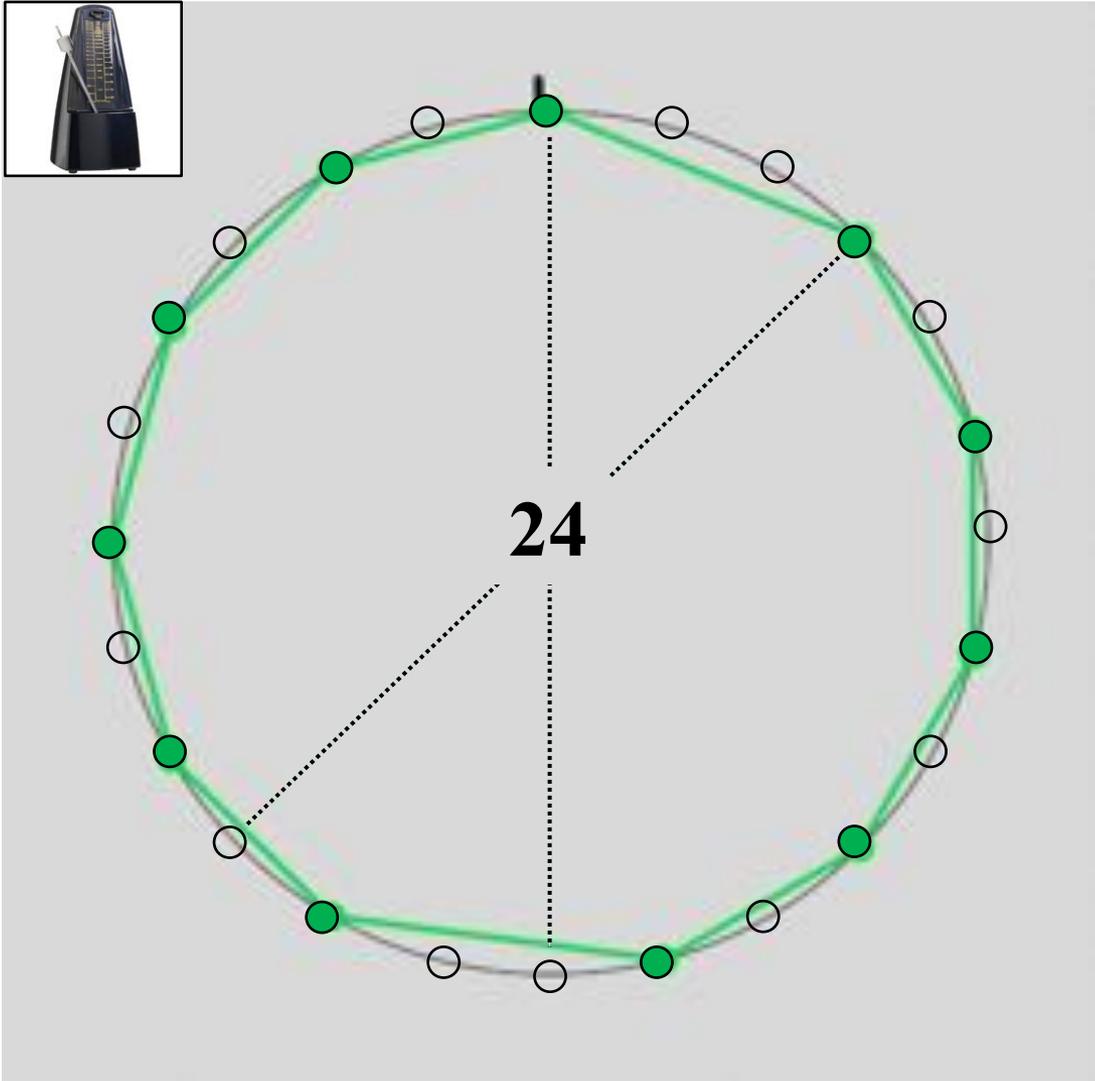


<http://www.josleys.com/Canon/Canon.html>

[min. 1'14"']



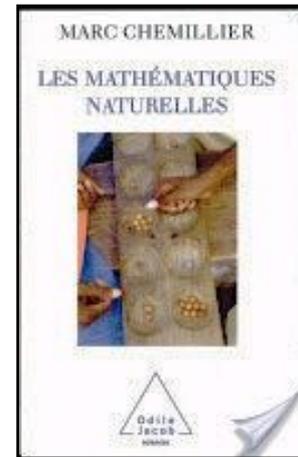
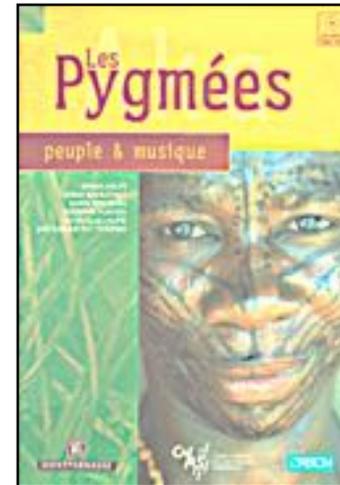
Imparité rythmique et traditions orales



Simha Arom



Marc Chemillier

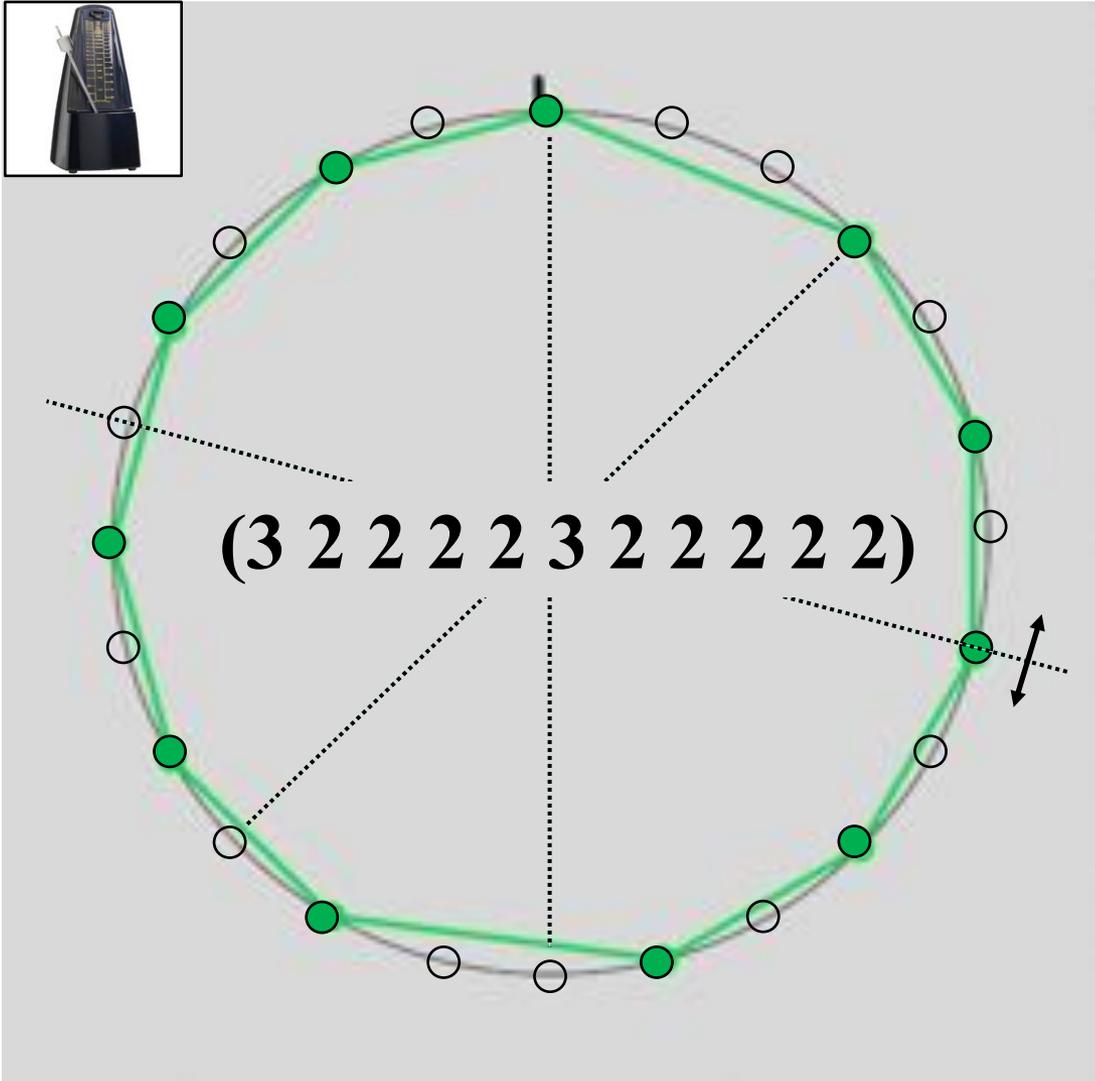


musimédiane

publiée avec le concours de la SFAM

revue audiovisuelle et multimédia d'analyse musicale

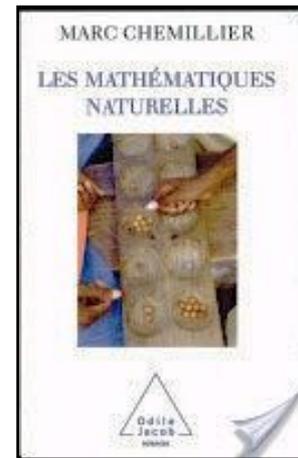
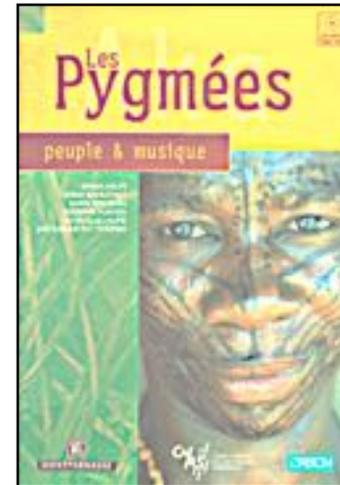
Imparité rythmique et traditions orales



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Le « cercle rythmique » et ses rotations

CLAPPING MUSIC

FOR TWO PERFORMERS

J. 004-100

CLAP 1
CLAP 2

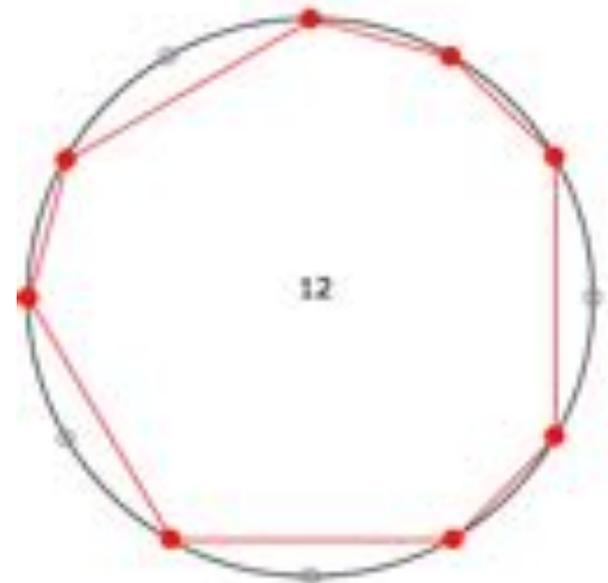
Repeat back to 1, then end

The performers begin and end with both performers in unison at bar ①. The number of repeats of each bar should be fixed at twelve repeats per bar. Since the first performer part does not change, it is up to the second performer to ease from one bar to the next. The second performer should try to keep his or her claps close to the first part of each measure (not on the first beat of the group of three claps), so that his claps always fall on a new beat of his or her underlying pattern.

The choice of a particular clapping sound, ie, with cupped or flat hands is left up to the performers, whichever sound is chosen, both performers should try to get the same one so that their two parts will blend to produce one overall exciting pattern.

Clapping Music de Steve Reich (1972)

Steve Reich 1972
12 repeats 1972



Le « cercle rythmique » et ses rotations

CLAPPING MUSIC

FOR TWO PERFORMERS

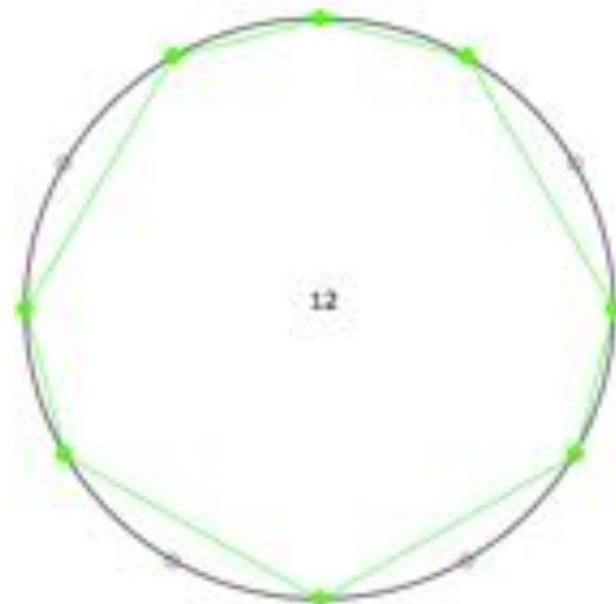
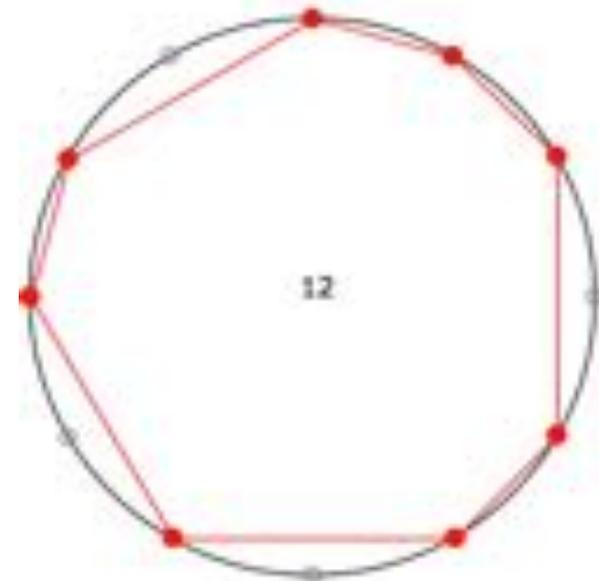
CLAP 1
CLAP 2

J. 044-100

Repeat last 12, then end

The performers begin and end with both performers in unison at bar ①. The number of repeats of each bar should be fixed at twelve repeats per bar. Since the first performer part does not change, it is up to the second performer to ease from one bar to the next. The second performer should try to keep his or her direction where it is written, i.e. on the first beat of each measure (not on the first beat of the group of three claps), so that his direction always falls on a new beat of his or her unchanging pattern.

The choice of a particular clapping sound, i.e. with cupped or flat hands is left up to the performers, whichever sound is chosen, both performers should try to get the same one so that their two parts will blend to produce one overall rhythmic pattern.



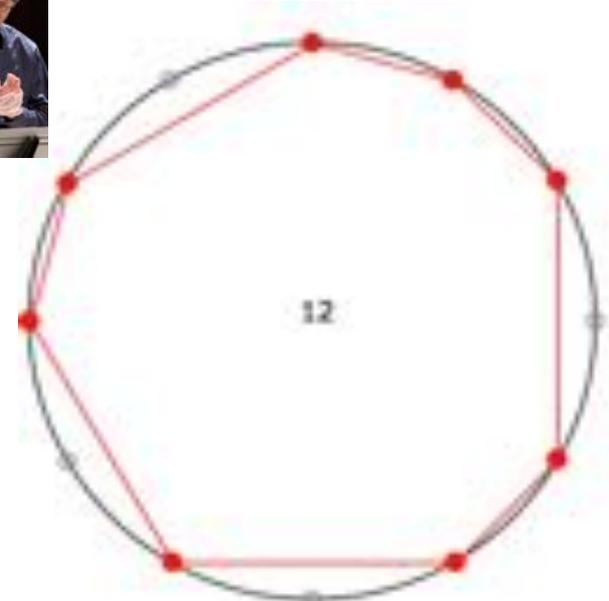
Le « cercle rythmique » et ses rotations

CLAPPING MUSIC

FOR TWO PERFORMERS



Handwritten musical notation for two clappers (CLAP 1 and CLAP 2). The notation is organized into measures, with some measures highlighted by colored boxes: a red box around the first measure, a green box around the second measure, and an orange box around the third measure. The notation includes rhythmic symbols and numbers indicating claps.



The performers begin and end with both performers in unison at bar ①. The number of repeats of each bar should be fixed at twelve repeats per bar. Since the first performer part does not change, it is up to the second performer to create five new bars to the next. The second performer should try to keep his or her drumbeat where it is written, i.e. on the first beat of each measure (not on the first beat of the group of three claps), so that his drumbeat always falls on a new beat of his or her unchanging pattern.

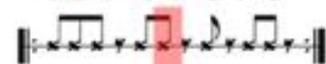
The choice of a particular clapping sound, i.e. with cupped or flat hands is left up to the performers, whereas tempo is chosen, both performers, should try to get the same one so that their two parts will blend to produce one overall exciting pattern.

*Steve Reich 12/72
revised 1/79*

Clapping Music (1972)

YOUTUBE.COM/GERUBACH

1 2 3 4 5 6 7 8



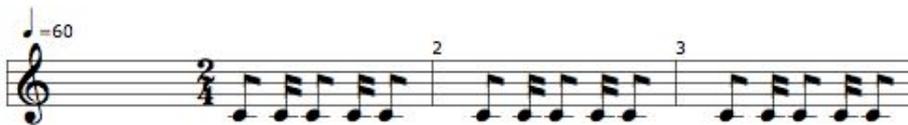
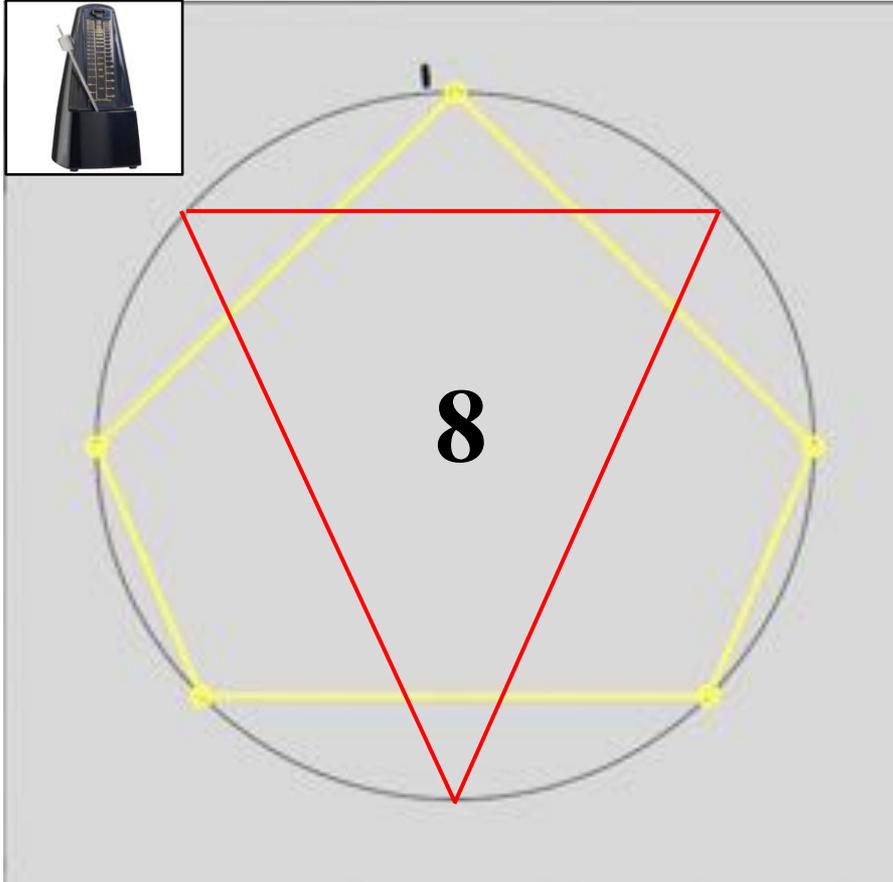
(SHIFT)

YOUTUBE.COM/GERUBACH

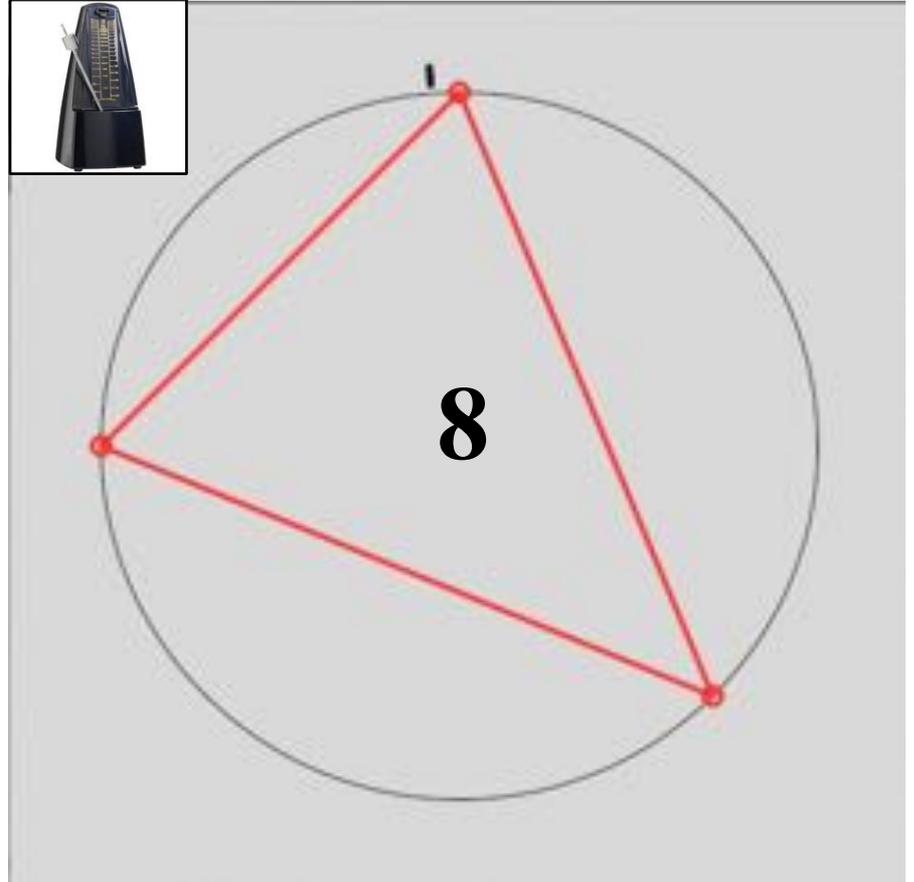
Gerubach's Scrolling Score Project
<http://www.gerubach.com>

Rythmes afro-cubains et symétries

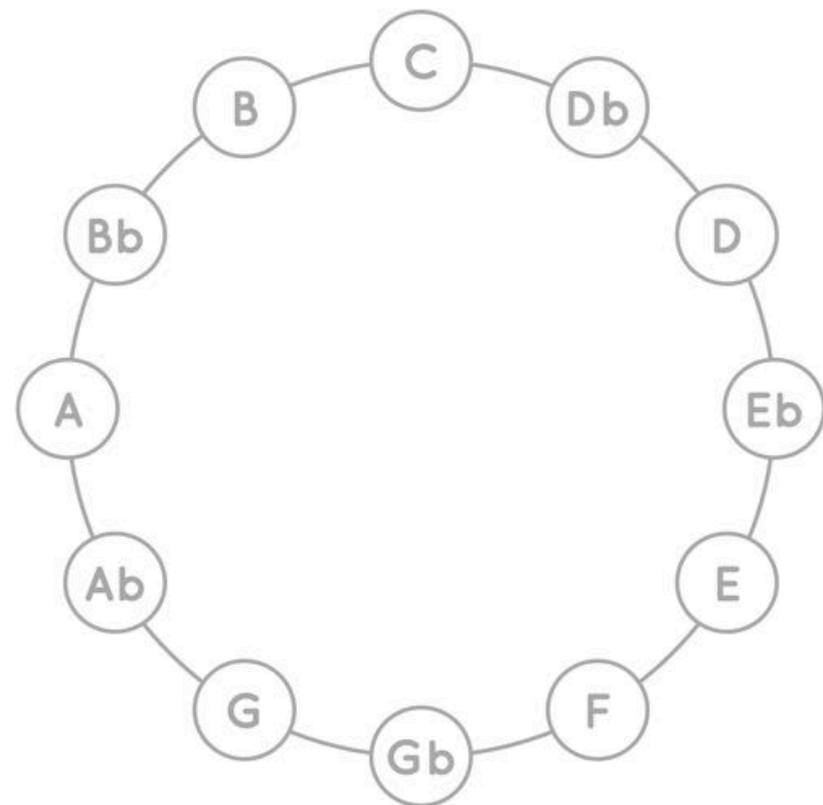
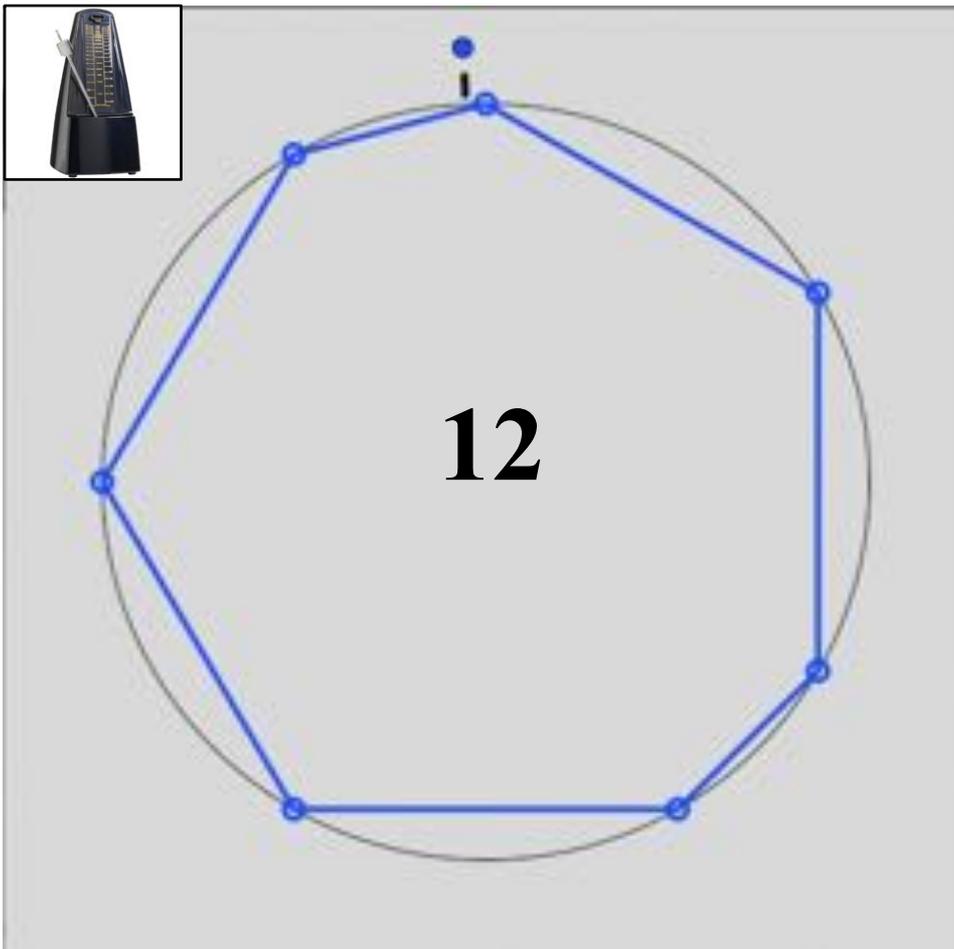
El cinquillo



El trecillo



Représentation circulaire des rythmes

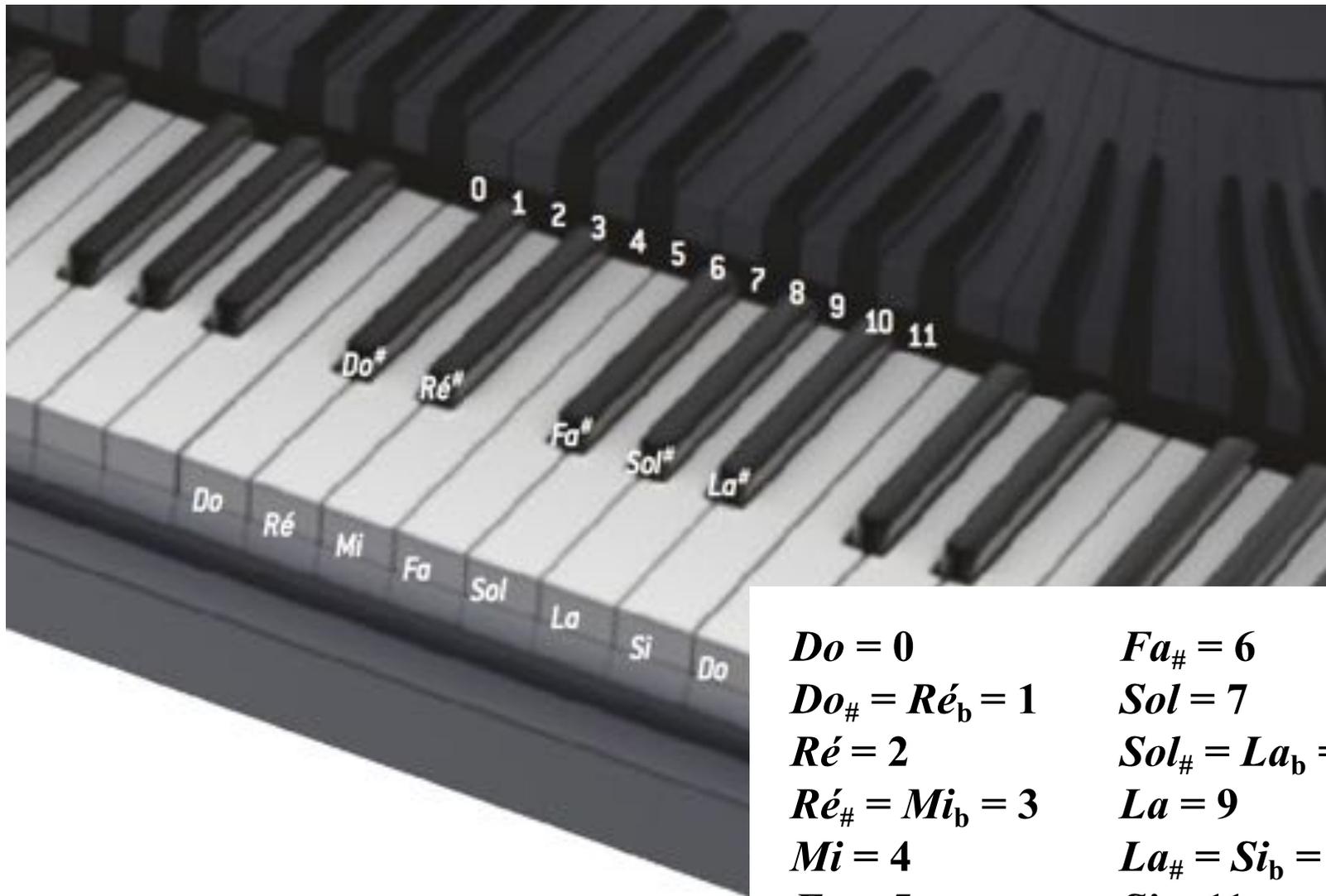


Abadja ou Bembé

Le piano : douze notes = douze nombres



Le piano : douze notes = douze nombres



Do = 0

*Do*_# = *Ré*_b = 1

Ré = 2

*Ré*_# = *Mi*_b = 3

Mi = 4

Fa = 5

*Fa*_# = 6

Sol = 7

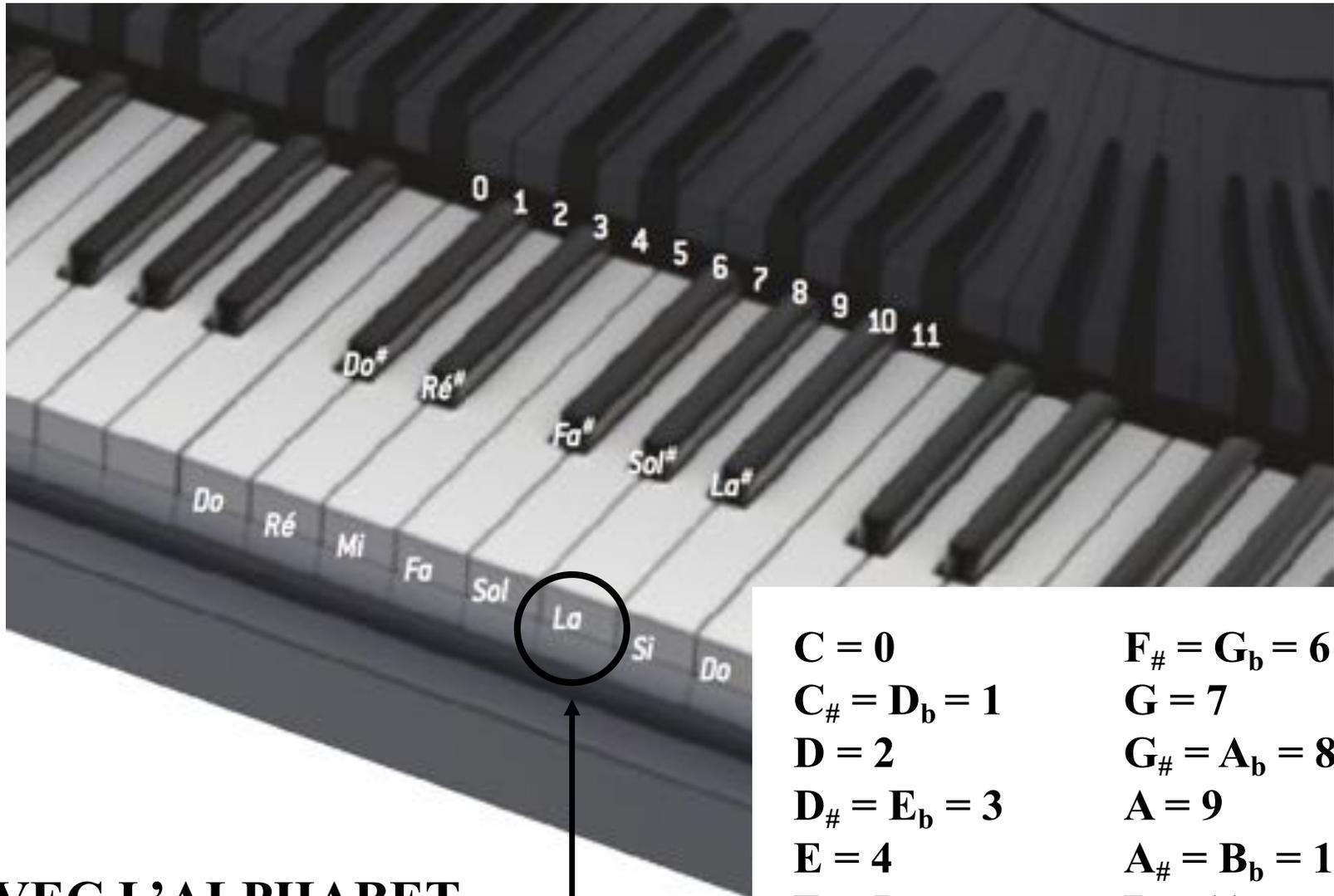
*Sol*_# = *La*_b = 8

La = 9

*La*_# = *Si*_b = 10

Si = 11

Le piano : douze notes = douze nombres



AVEC L'ALPHABET
A partir du *la* = A

$$C = 0$$

$$C\# = D_b = 1$$

$$D = 2$$

$$D\# = E_b = 3$$

$$E = 4$$

$$F = 5$$

$$F\# = G_b = 6$$

$$G = 7$$

$$G\# = A_b = 8$$

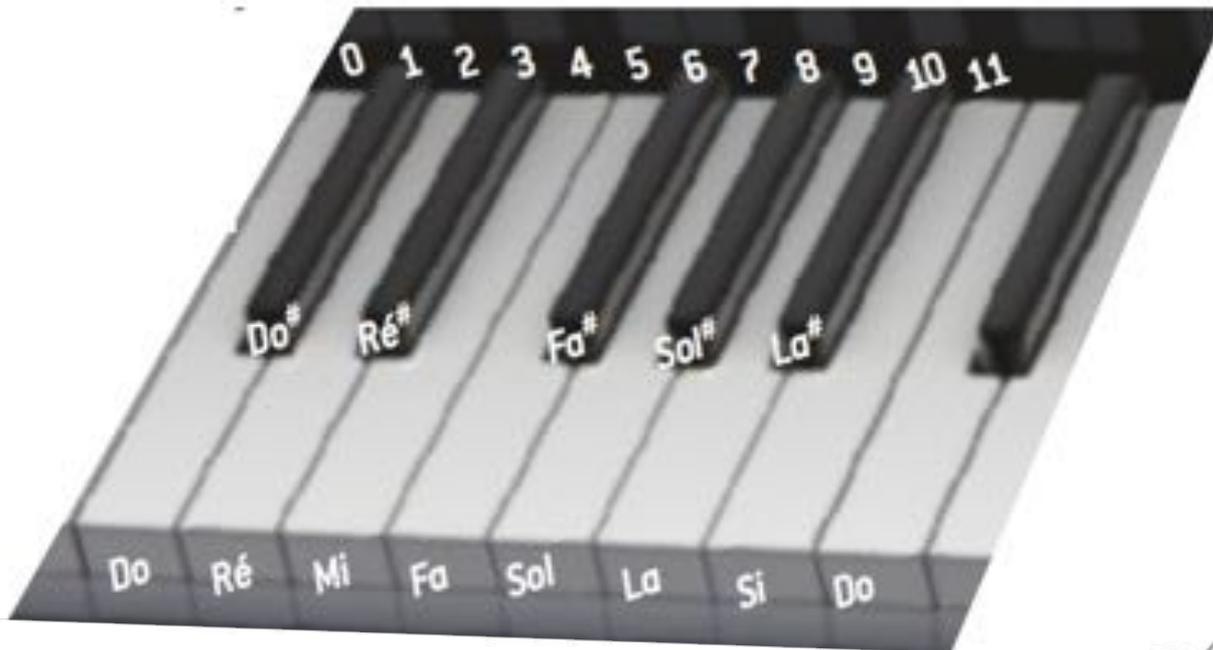
$$A = 9$$

$$A\# = B_b = 10$$

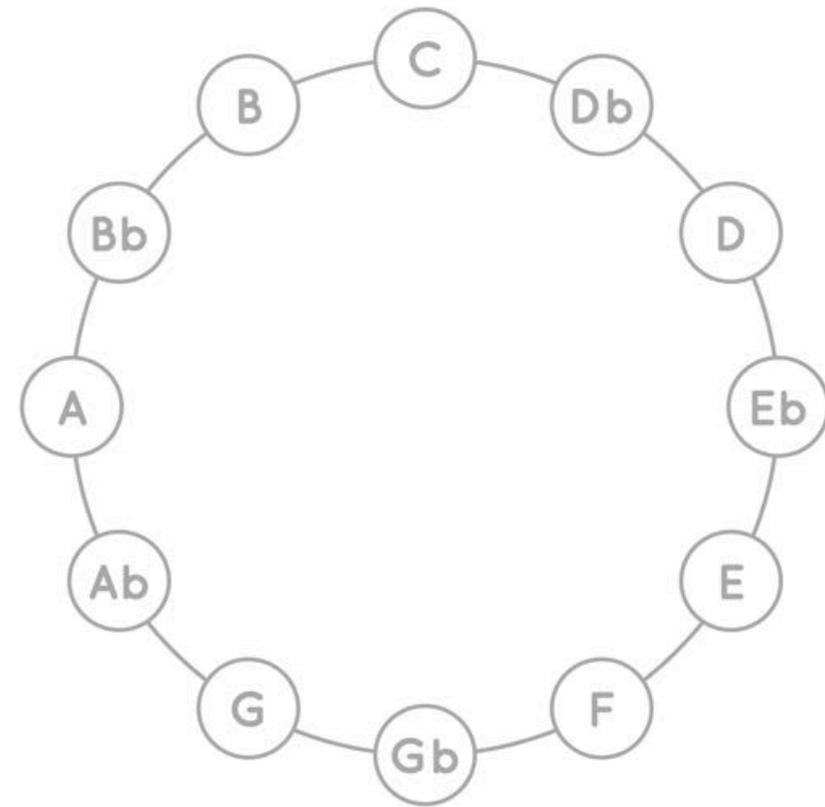
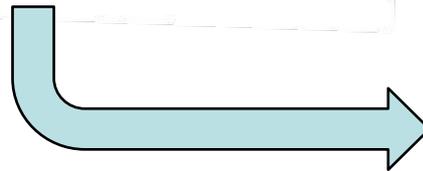
$$B = 11$$

Du piano à l'horloge musicale (notation anglo-saxonne)

➔ DEMO



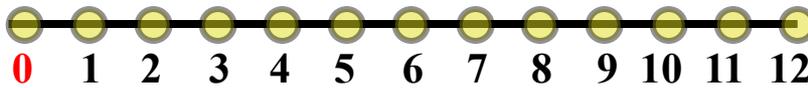
C = 0	F_# = G_b = 6
C_# = D_b = 1	G = 7
D = 2	G_# = A_b = 8
D_# = E_b = 3	A = 9
E = 4	A_# = B_b = 10
F = 5	B = 11



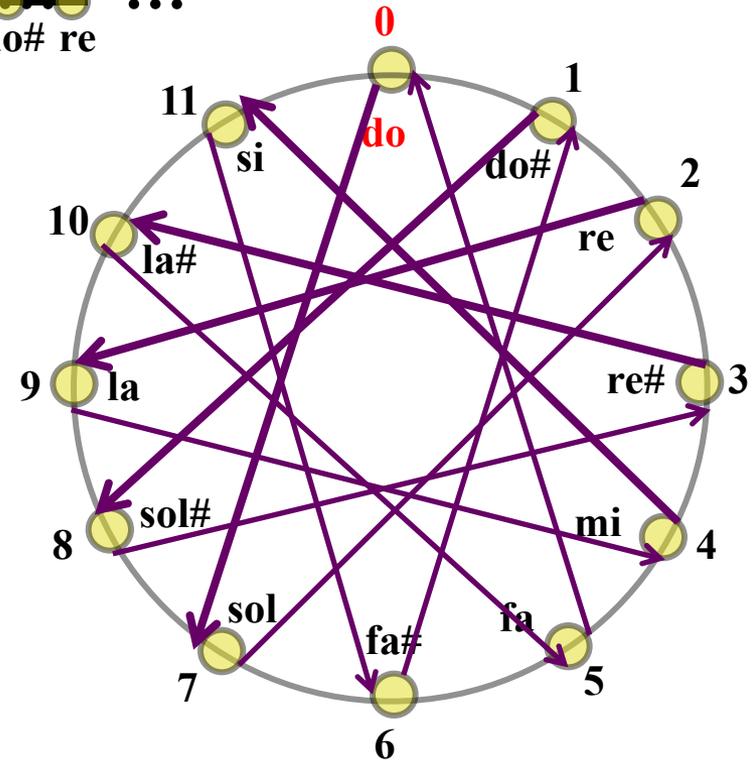
Quelques propriétés de quelques intervalles



7



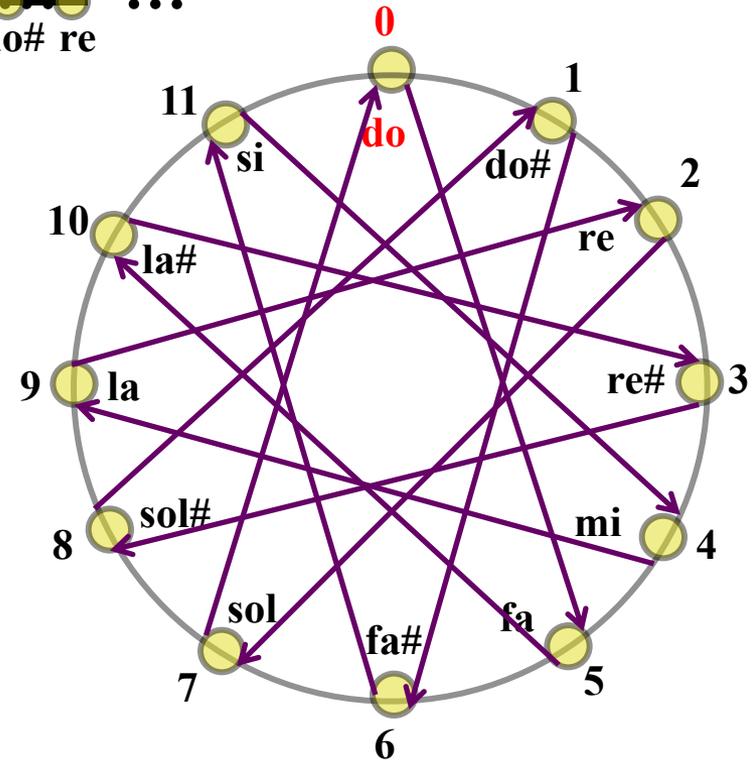
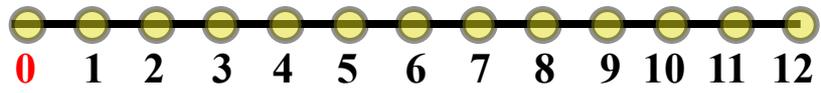
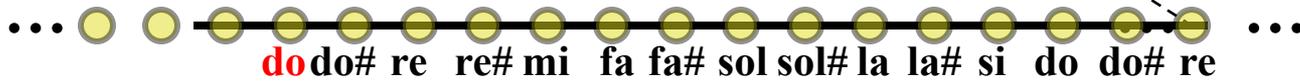
Cycle des quintes



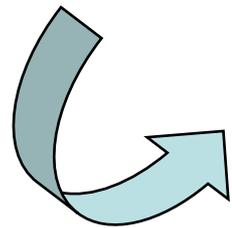
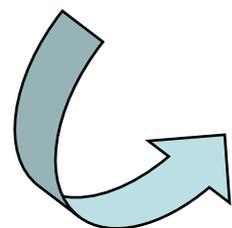
Quelques propriétés de quelques intervalles



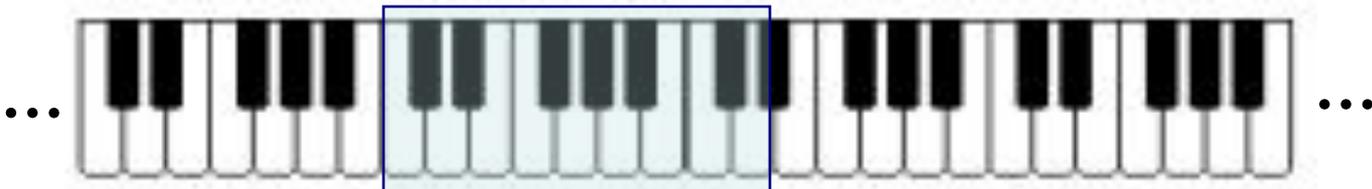
5



Cycle des quartes



Quelques propriétés de quelques intervalles

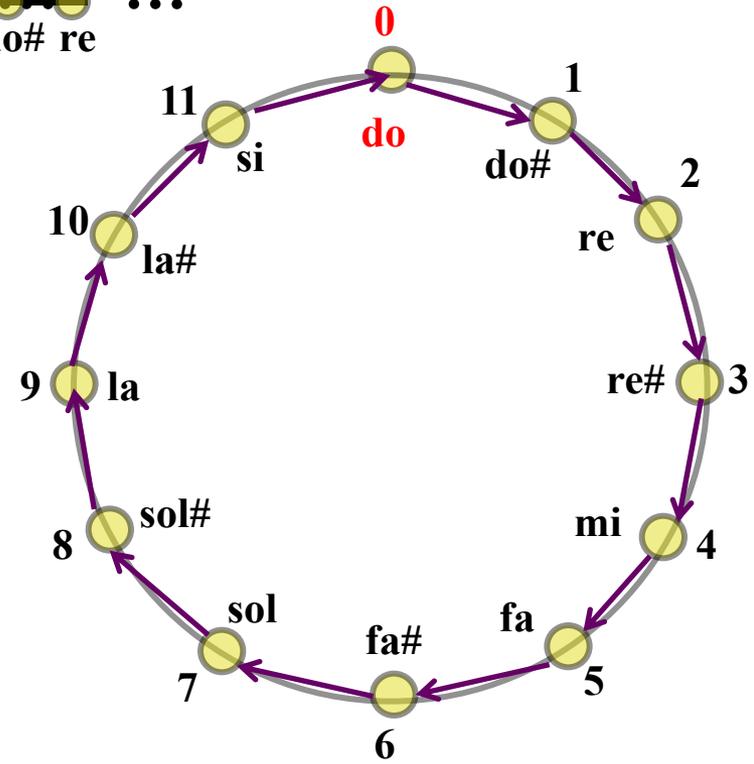


1

... do do# re re# mi fa fa# sol sol# la la# si do do# re ...



0 1 2 3 4 5 6 7 8 9 10 11 12



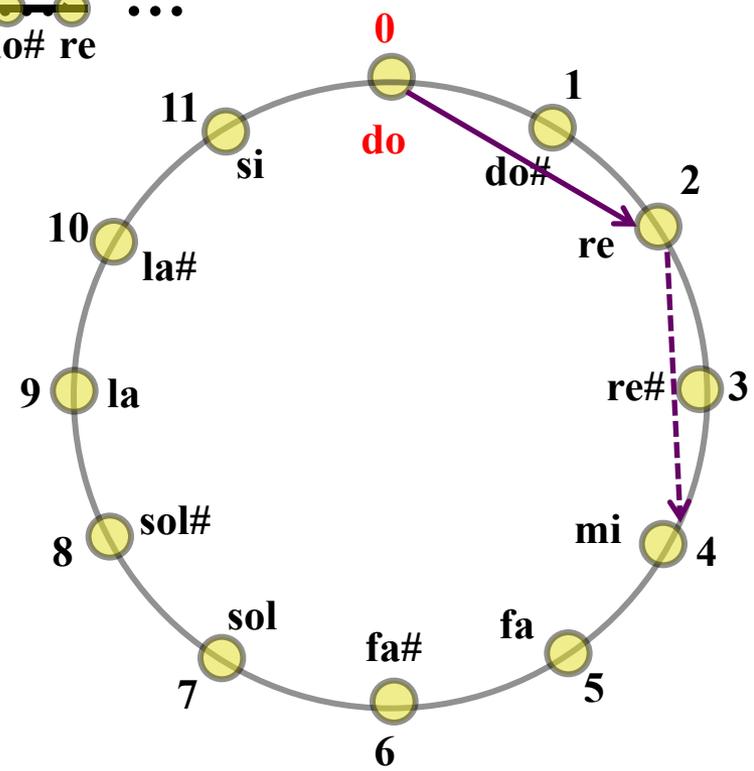
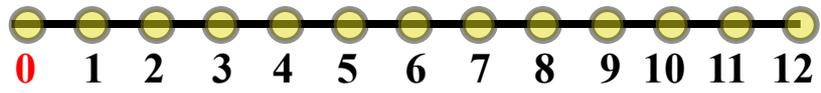
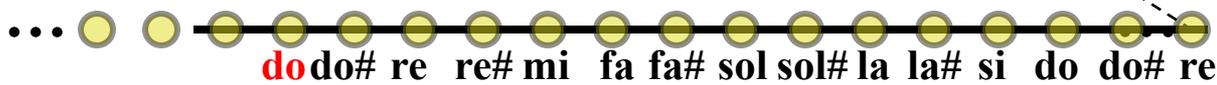
→ Quels sont les autres entiers qui engendrent le cercle ?

Quelques propriétés de quelques intervalles

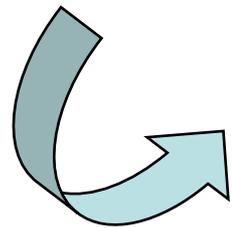


?

2



→ Quels sont les autres entiers qui engendrent le cercle ?



Pas tous les intervalles engendrent le cercle entier



?

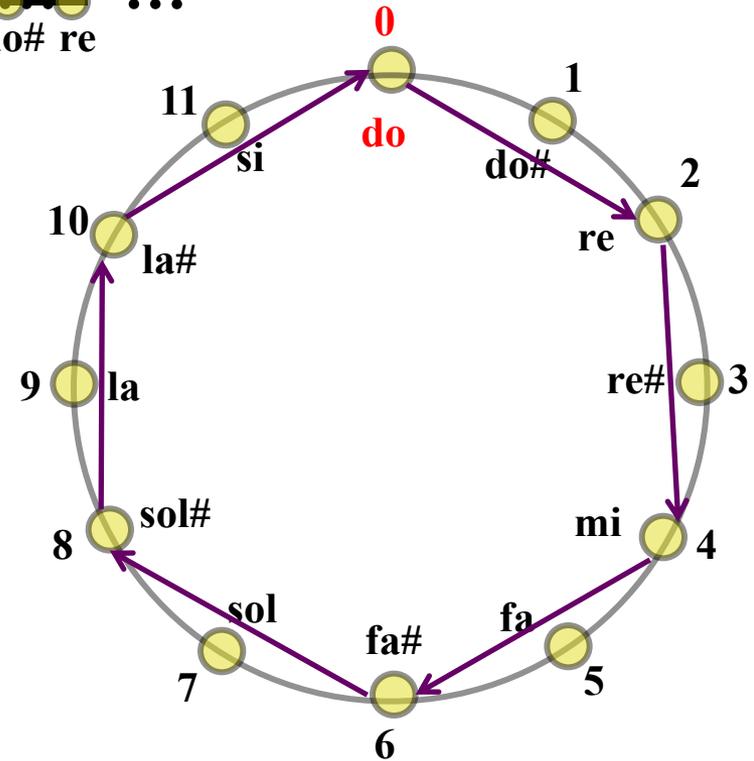
2

... ...

do do# re re# mi fa fa# sol sol# la la# si do do# re

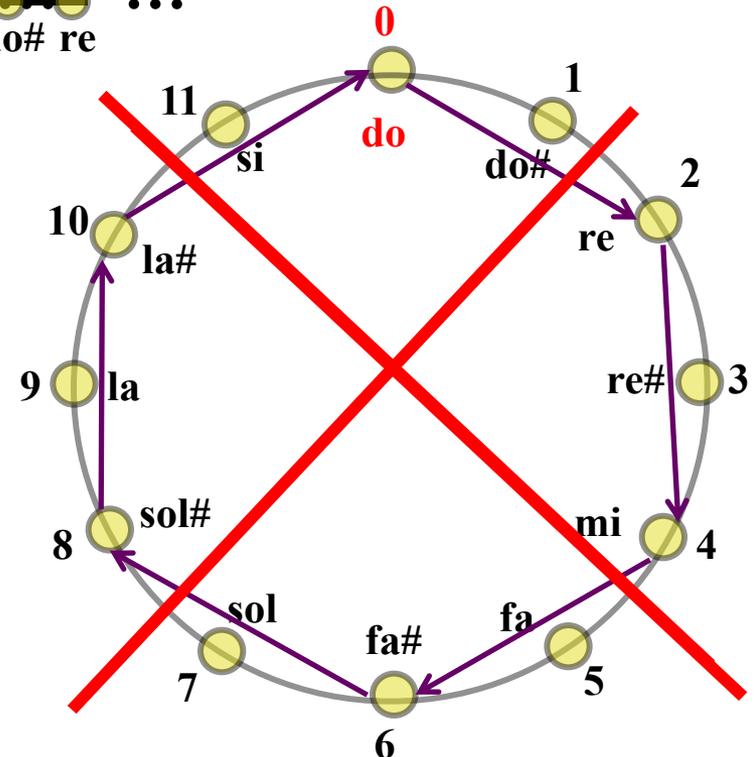
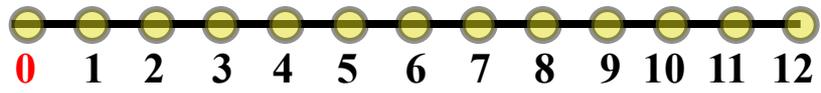
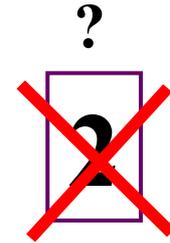
...

0 1 2 3 4 5 6 7 8 9 10 11 12



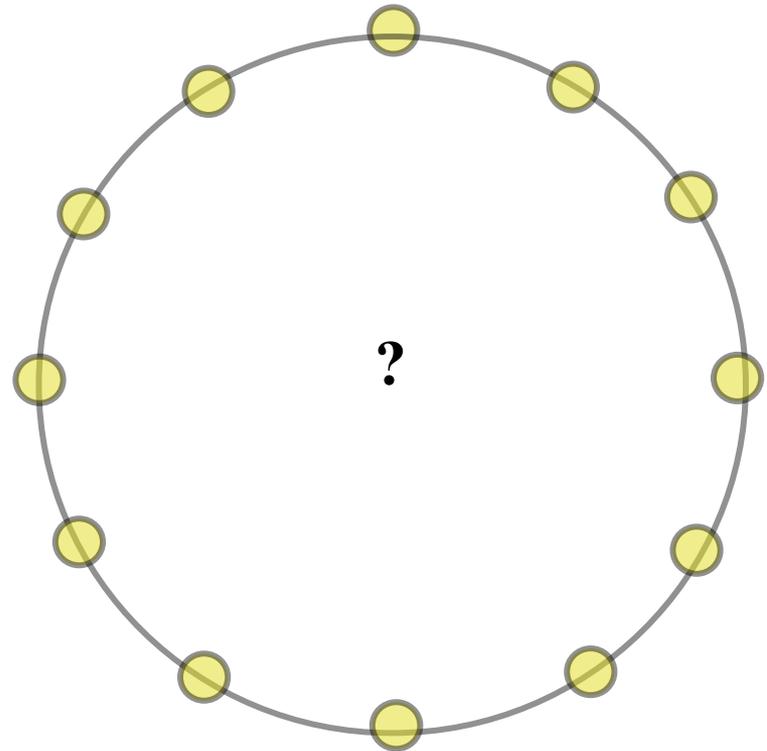
→ Quels sont les autres entiers qui engendrent le cercle ?

Pas tous les intervalles engendrent le cercle entier



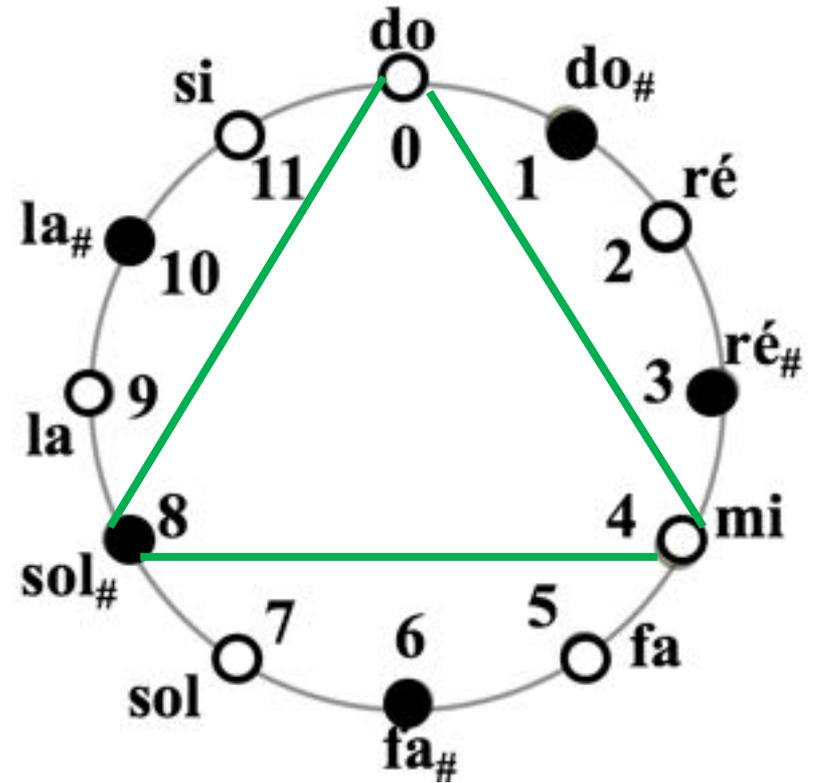
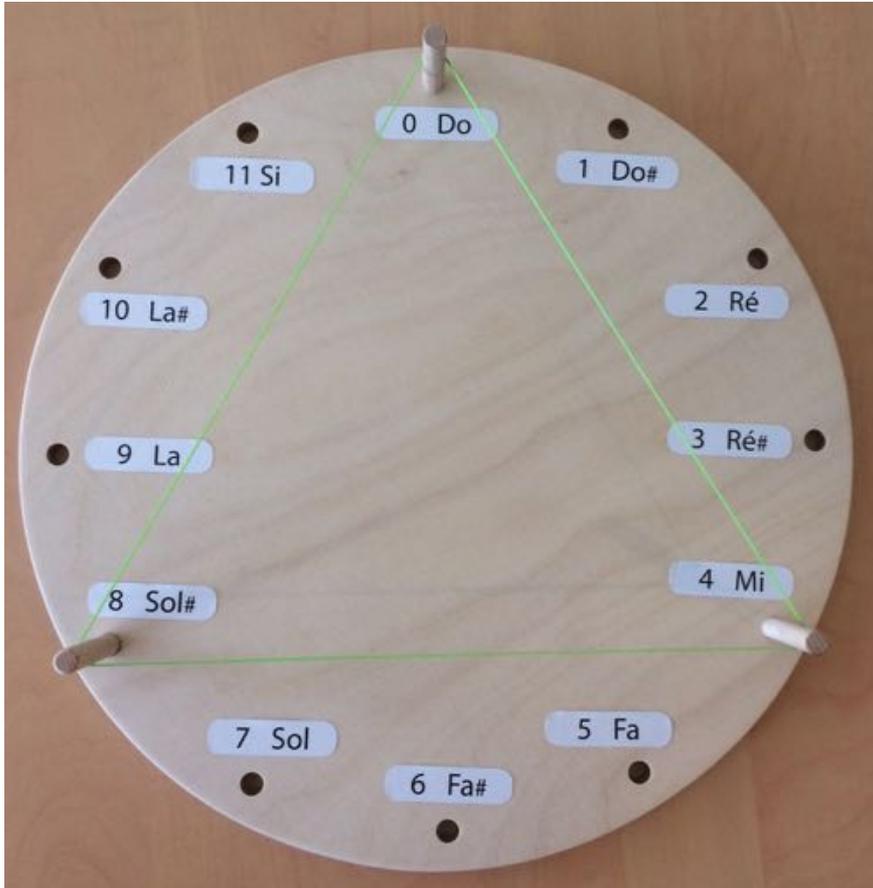
→ Quels sont les autres entiers qui engendrent le cercle ?

A vous de jouer...

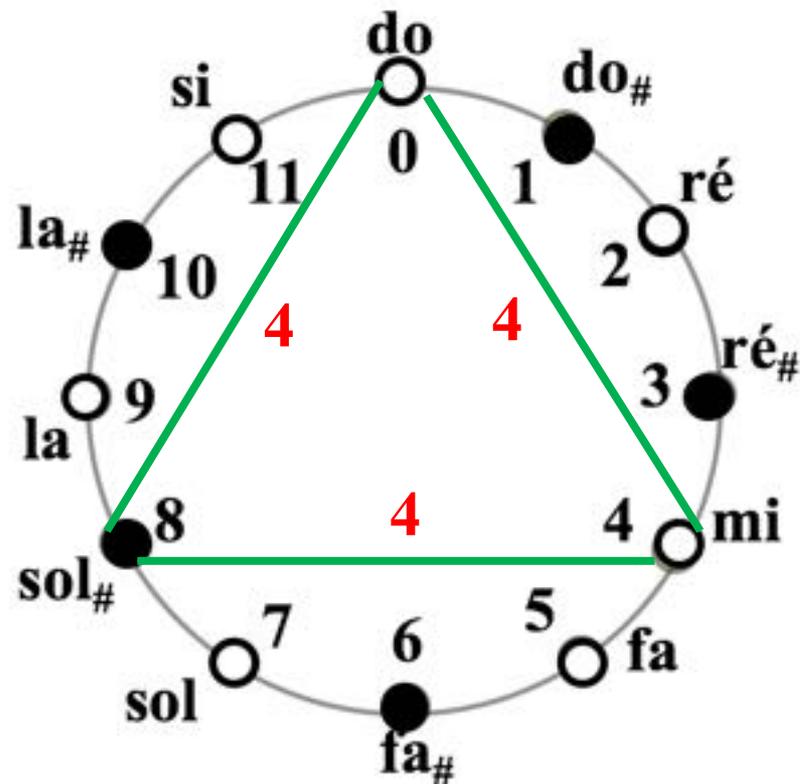
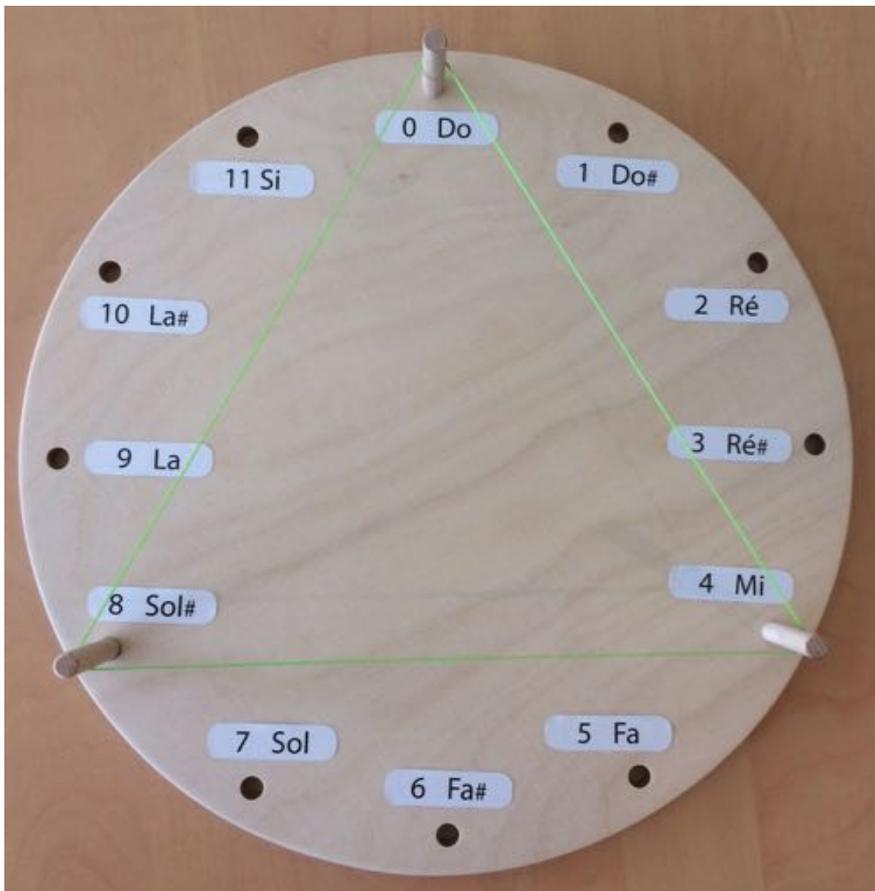


Quelle est la musique d'un triangle équilatéral ?

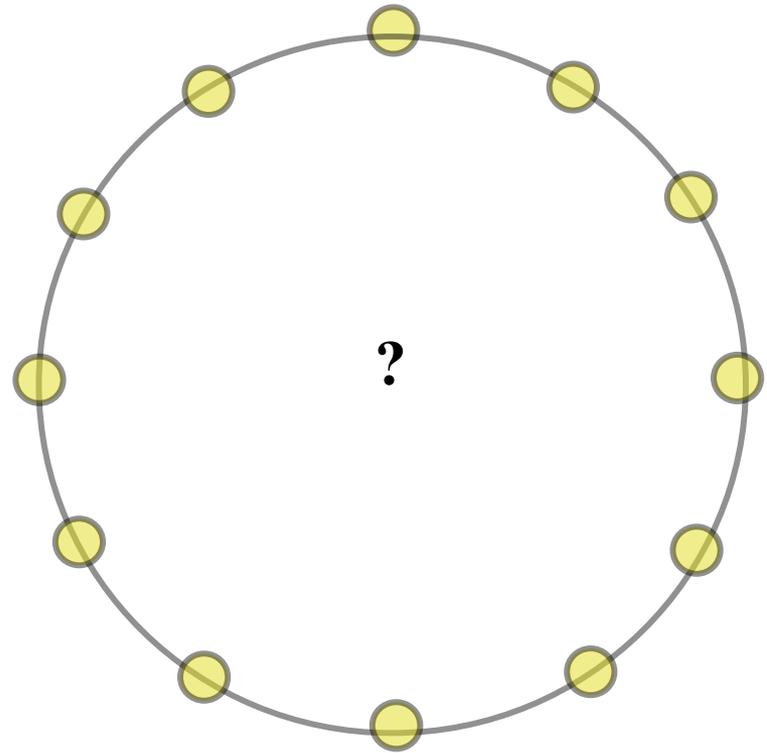
Le triangle équilatéral = l'accord augmenté



Le triangle équilatéral = l'accord augmenté ou (4, 4, 4)

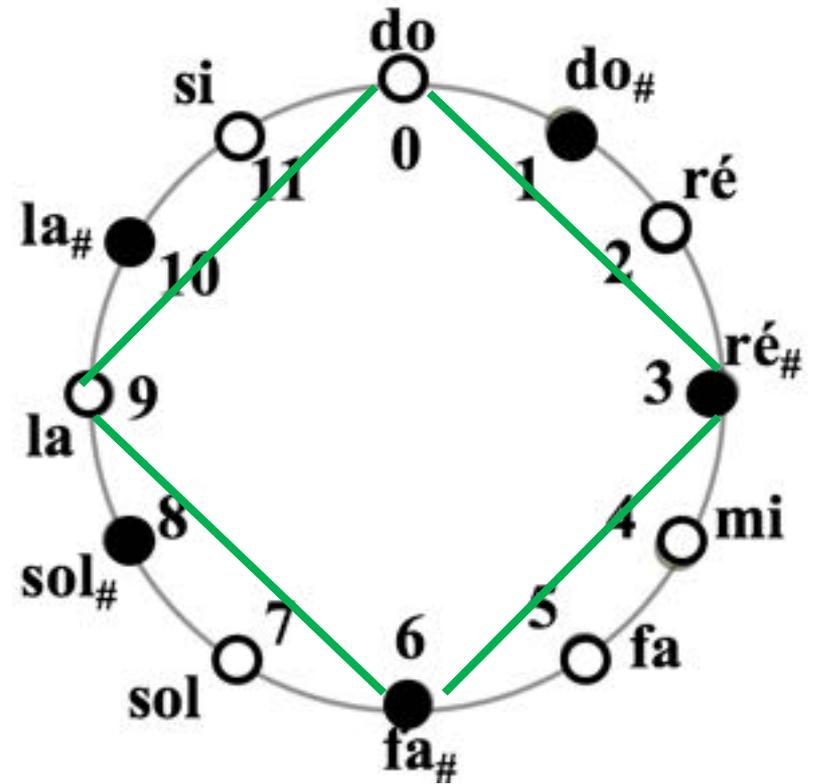
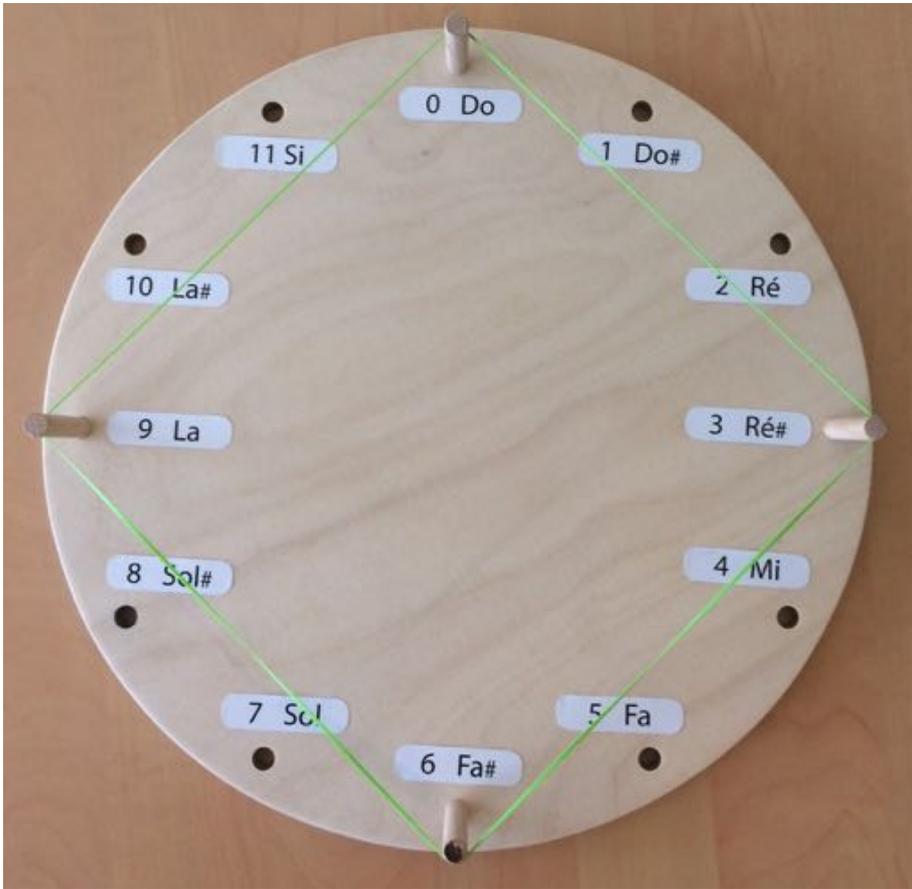


A vous de jouer...

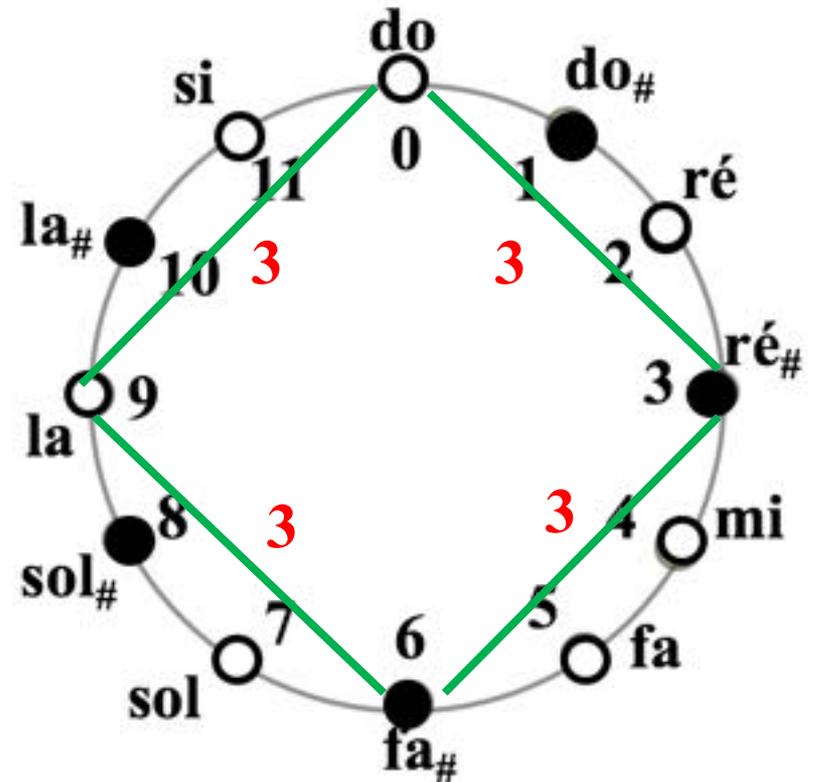
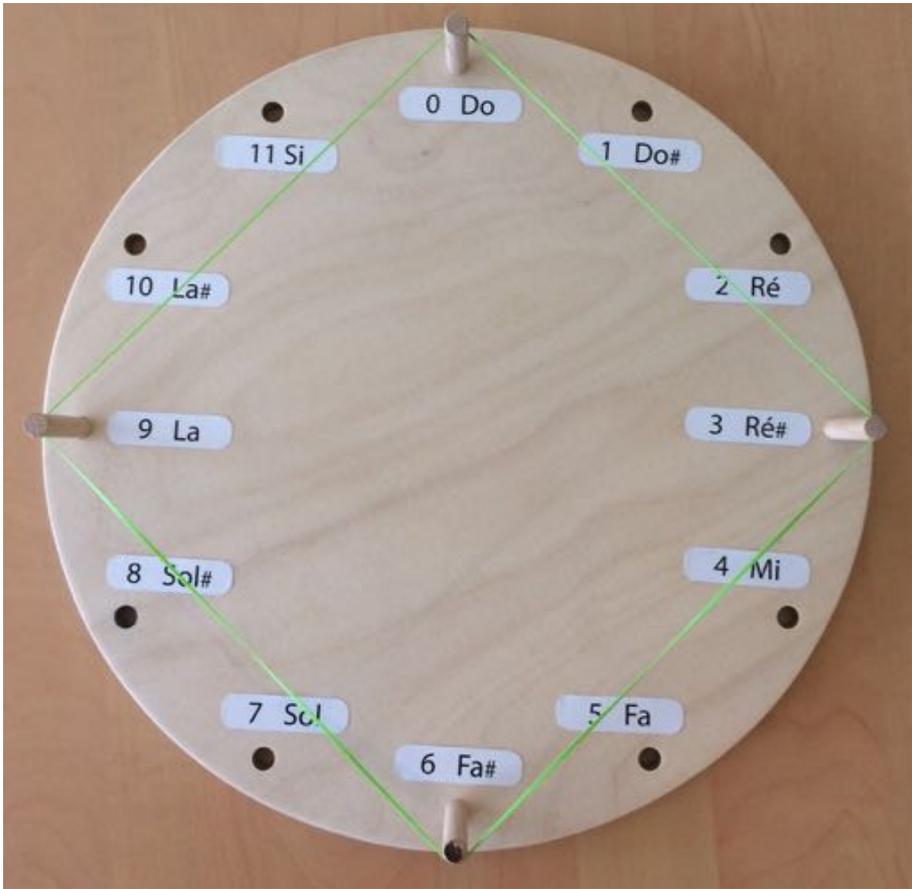


Quelle est la musique d'un carré ?

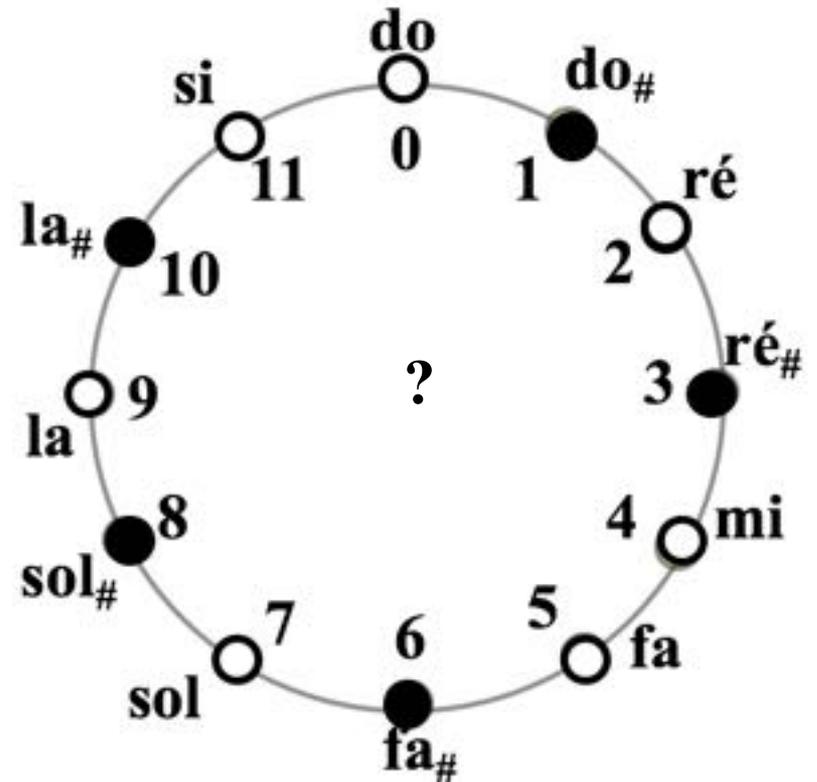
Le carré = l'accord diminué



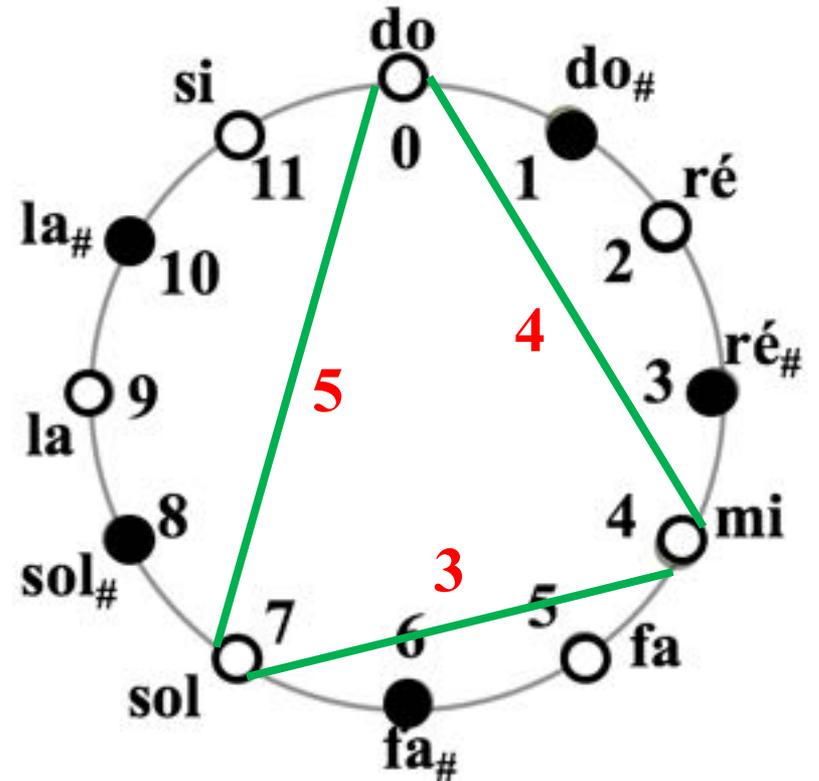
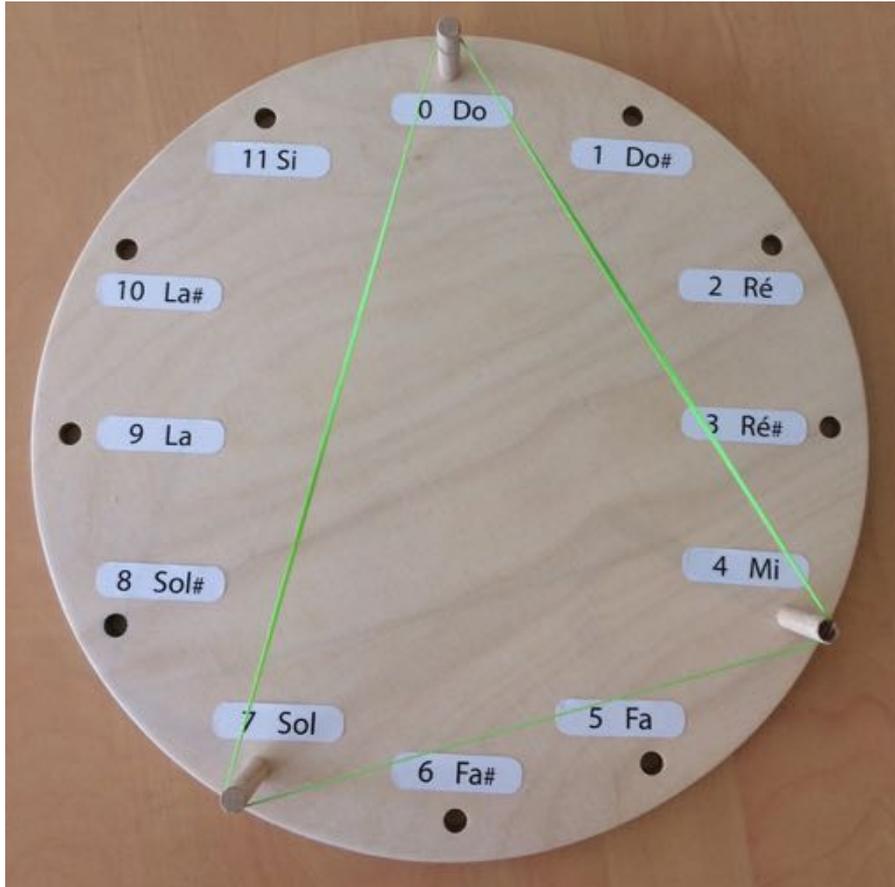
Le carré = l'accord diminué ou (3, 3, 3, 3)



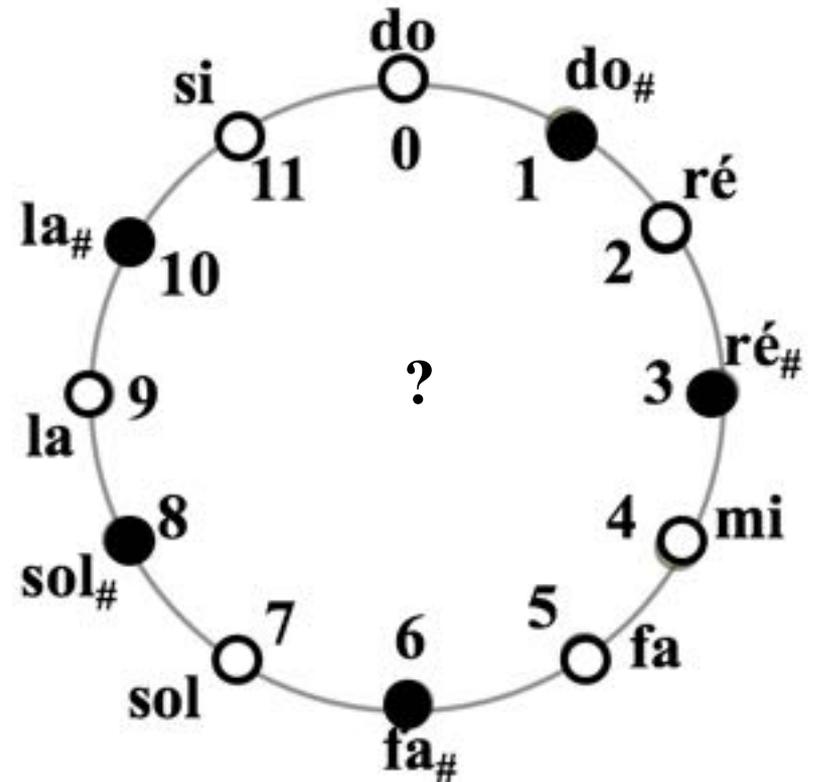
Dessine-moi l'accord majeur ou (4, 3, 5)



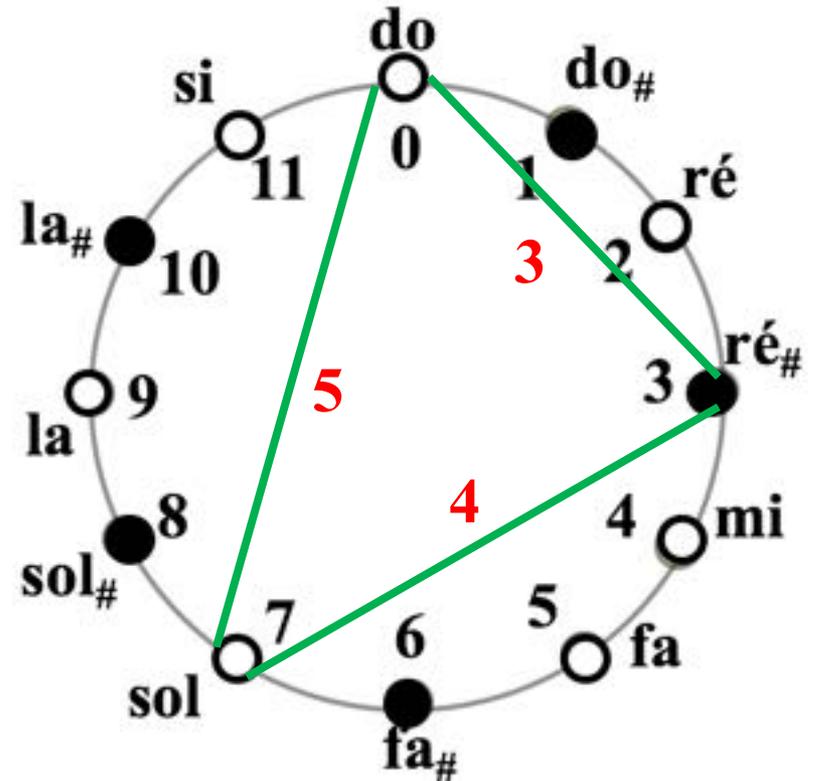
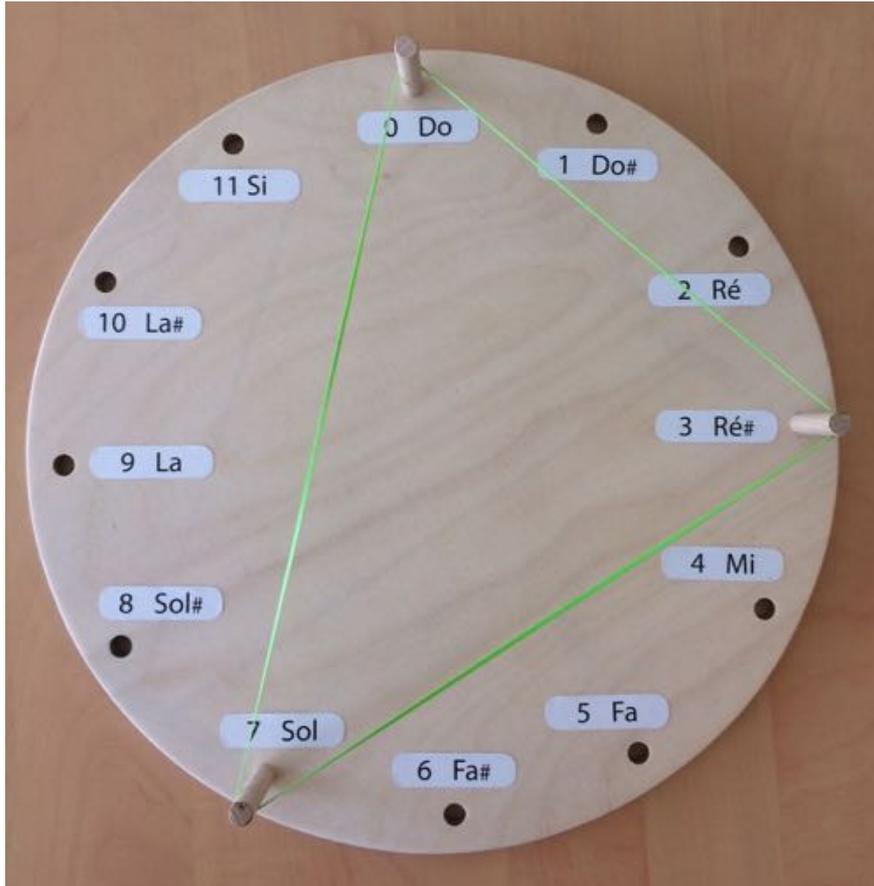
Dessine-moi l'accord majeur ou (4, 3, 5)



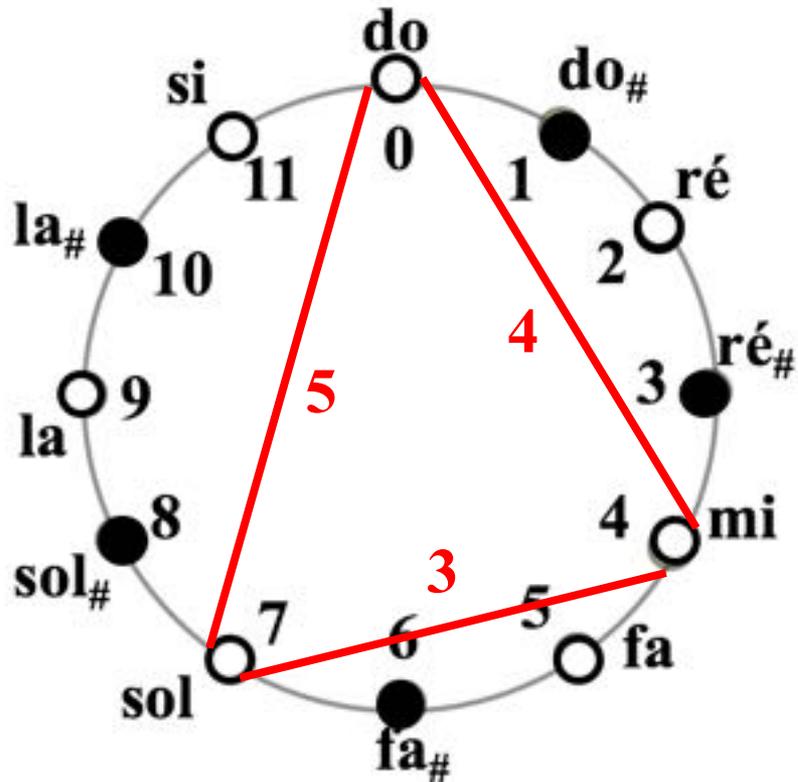
Dessine-moi l'accord mineur ou (3, 4, 5)



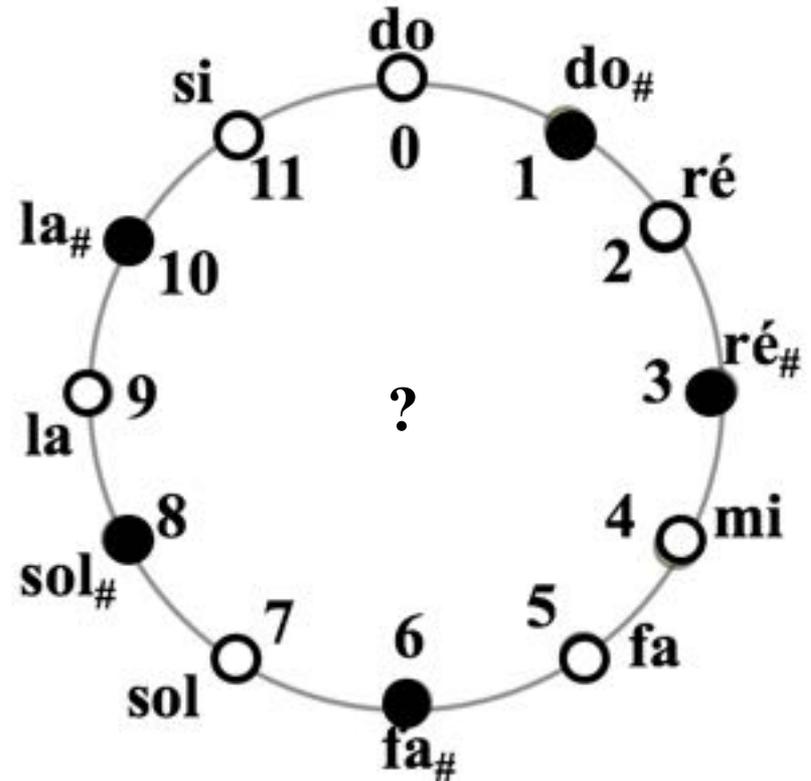
Dessine-moi l'accord mineur ou (3, 4, 5)



Dessine-moi deux accords majeurs

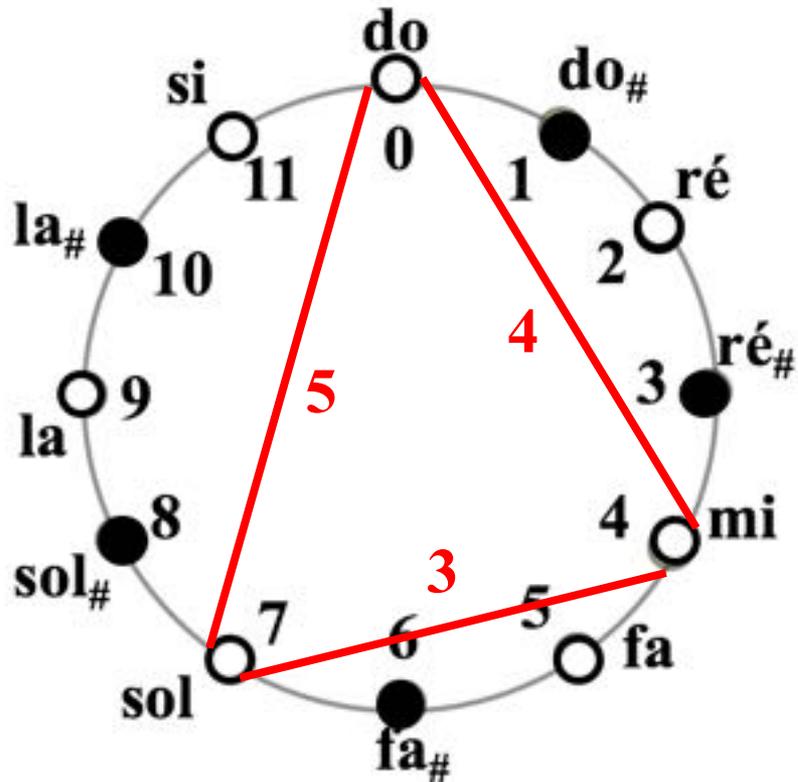


Do majeur

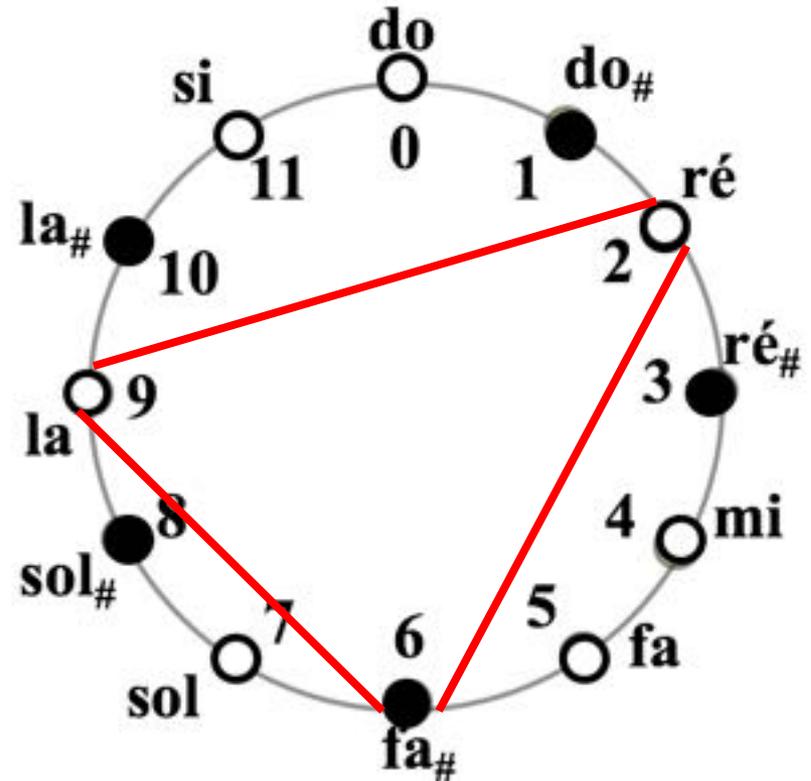


Ré majeur

Dessine-moi deux accords majeurs

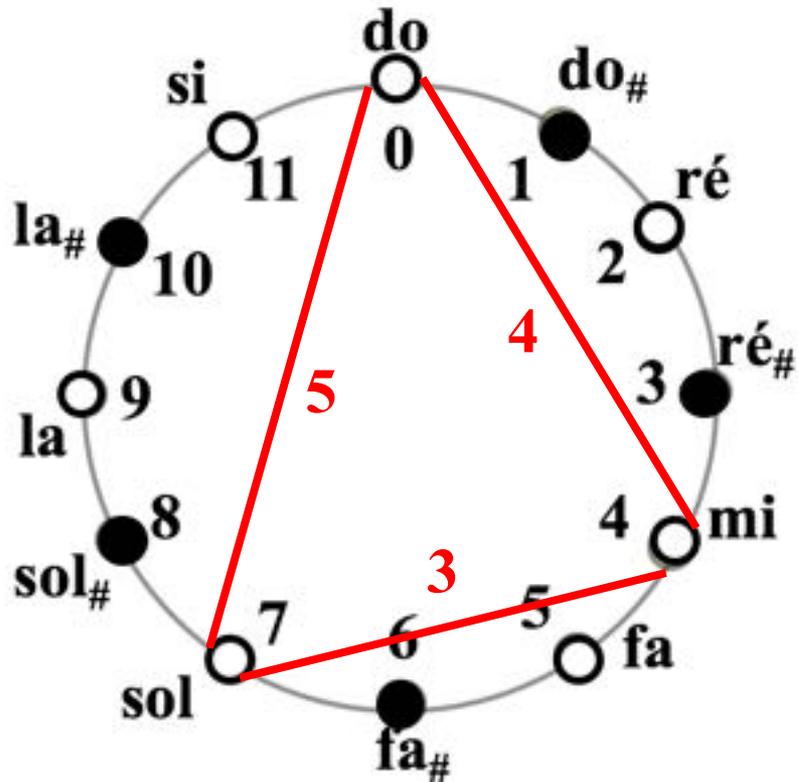


Do majeur

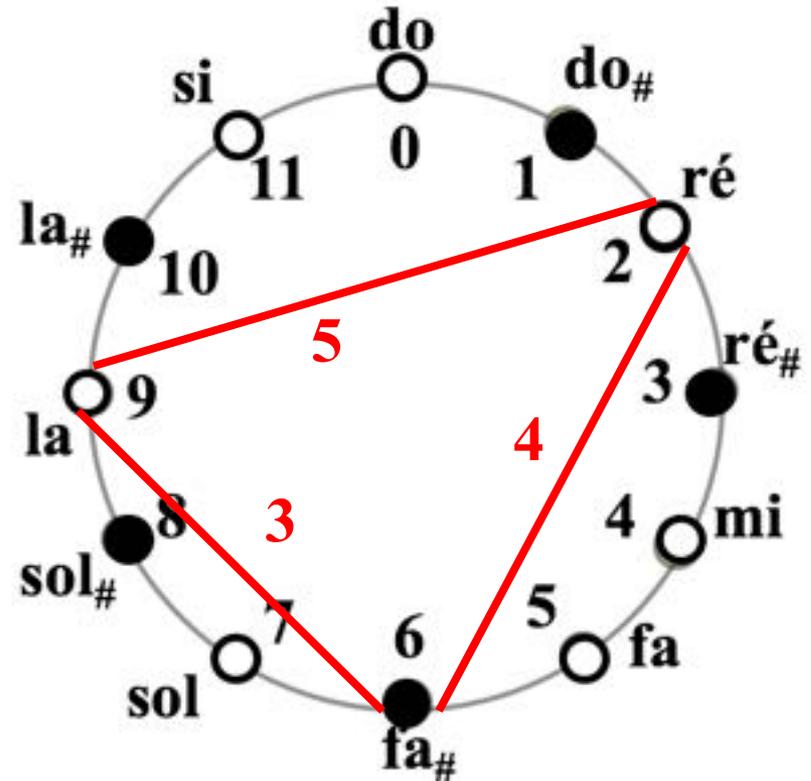


Ré majeur

Dessine-moi deux accords majeurs



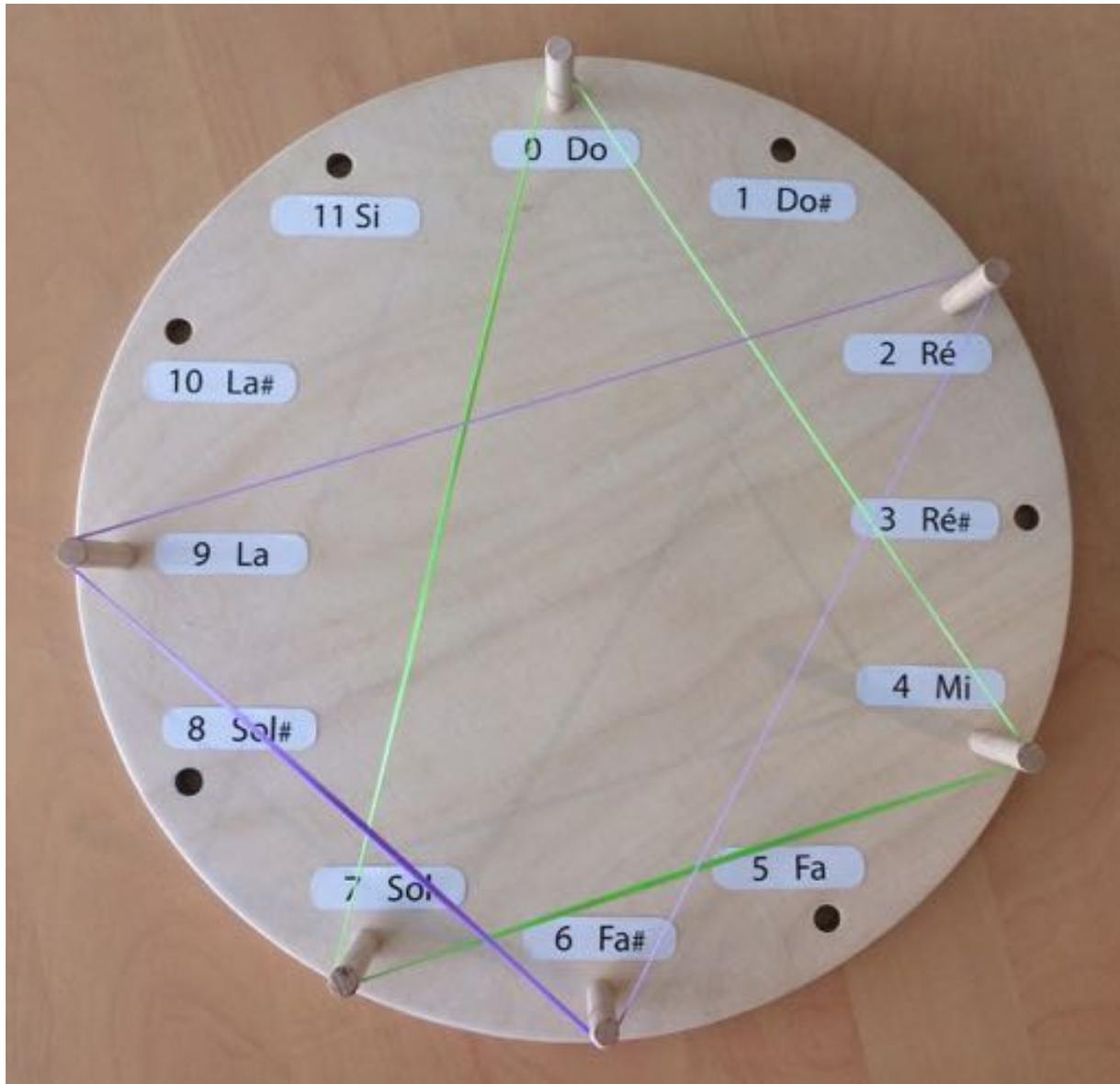
Do majeur



Ré majeur

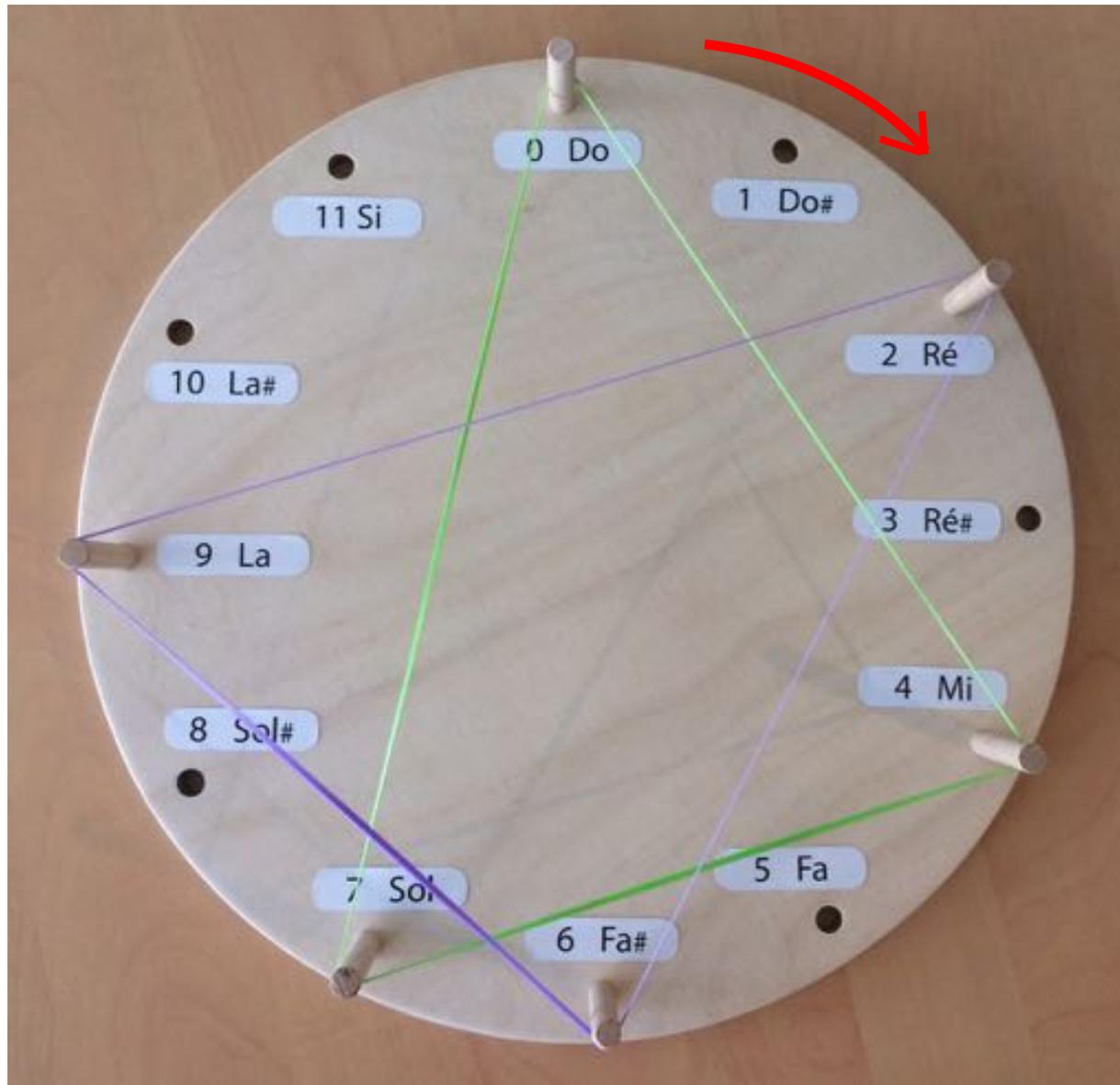
Quel est le rapport entre deux accords majeurs ?

On passe de l'un à l'autre via une ...



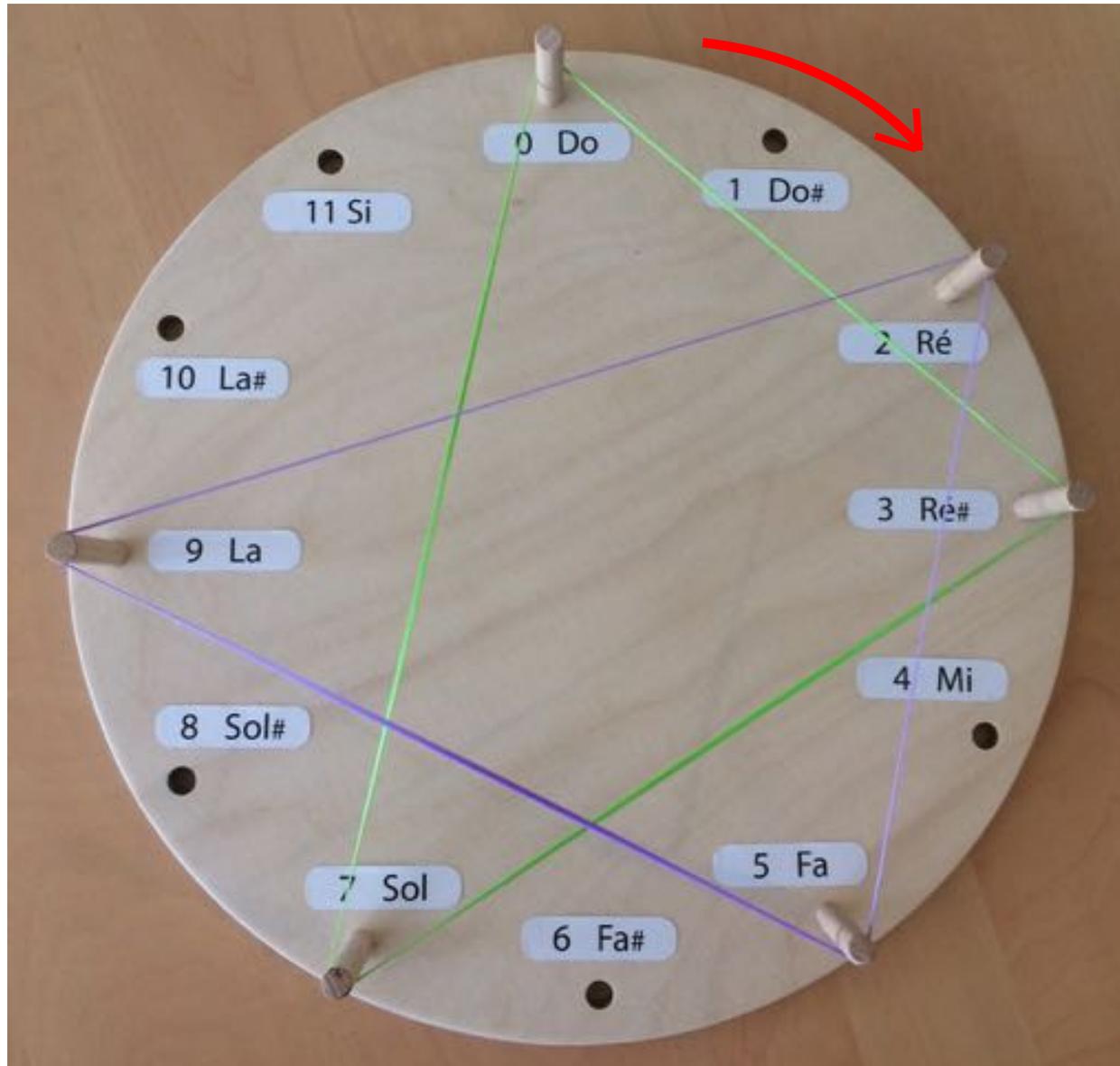
Quel est le rapport entre deux accords majeurs ?

On passe de l'un à l'autre via une **ROTATION**

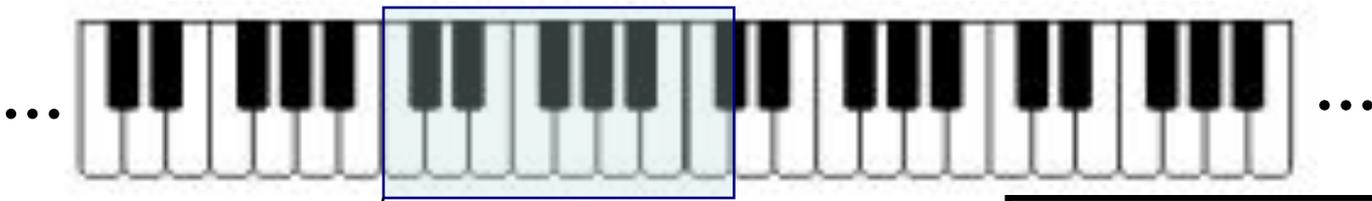


Quel est le rapport entre deux accords mineurs ?

On passe de l'un à l'autre via une **ROTATION**



Les rotations sont des additions...



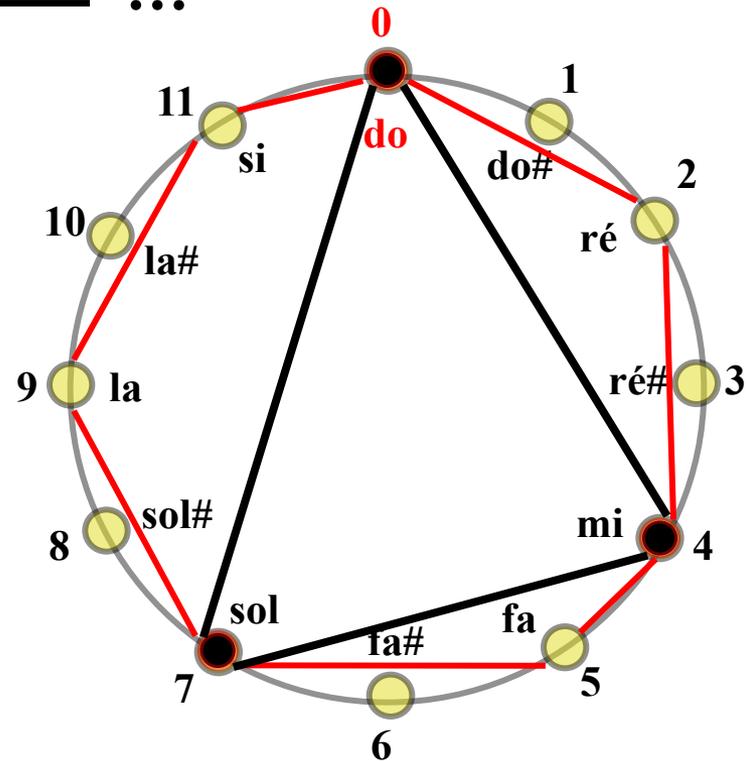
$$\text{Do maj} = \{0, 2, 4, 5, 7, 9, 11\} + 1$$



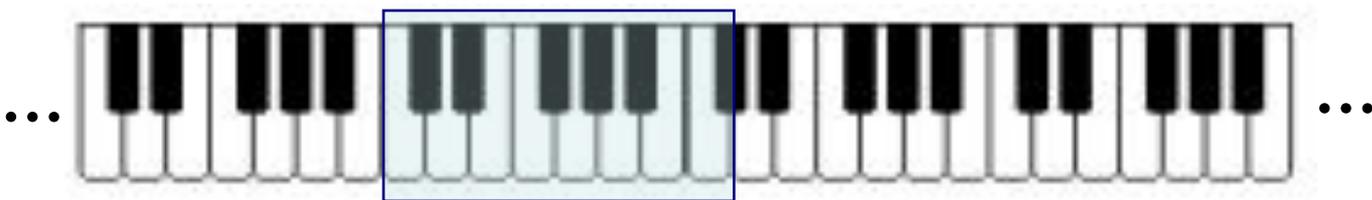
do do# ré ré# mi fa fa# sol sol# la la# si do



0 1 2 3 4 5 6 7 8 9 10 11 12



Les rotations sont des additions...

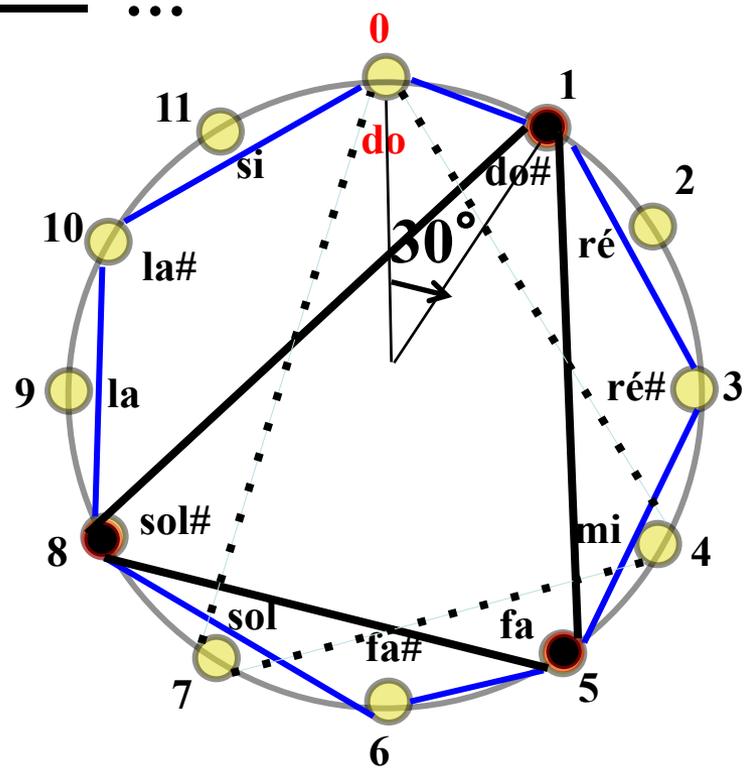


$$Do\# \text{ maj} = \{1, 3, 5, 6, 8, 10, 0\}$$

... do do# ré ré# mi fa fa# sol sol# la la# si do ...

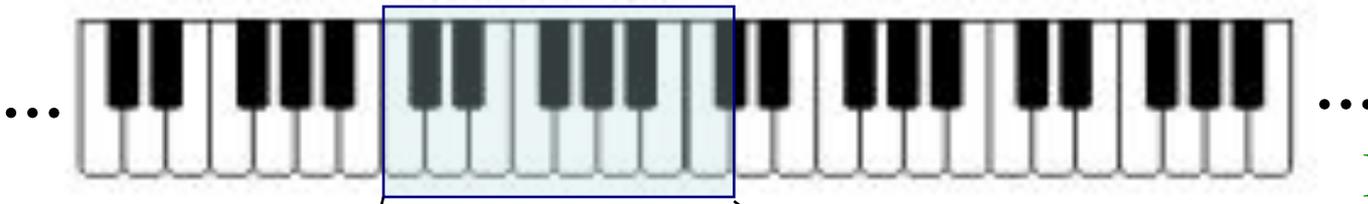
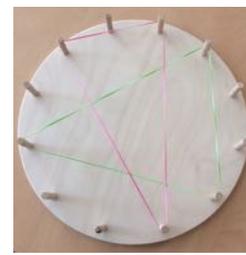


0 1 2 3 4 5 6 7 8 9 10 11 12



... ou des transpositions !

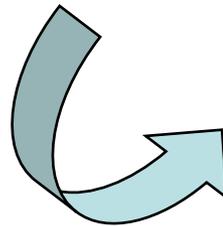
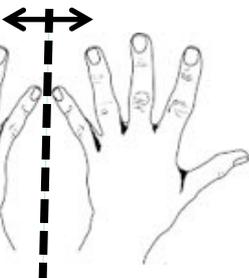
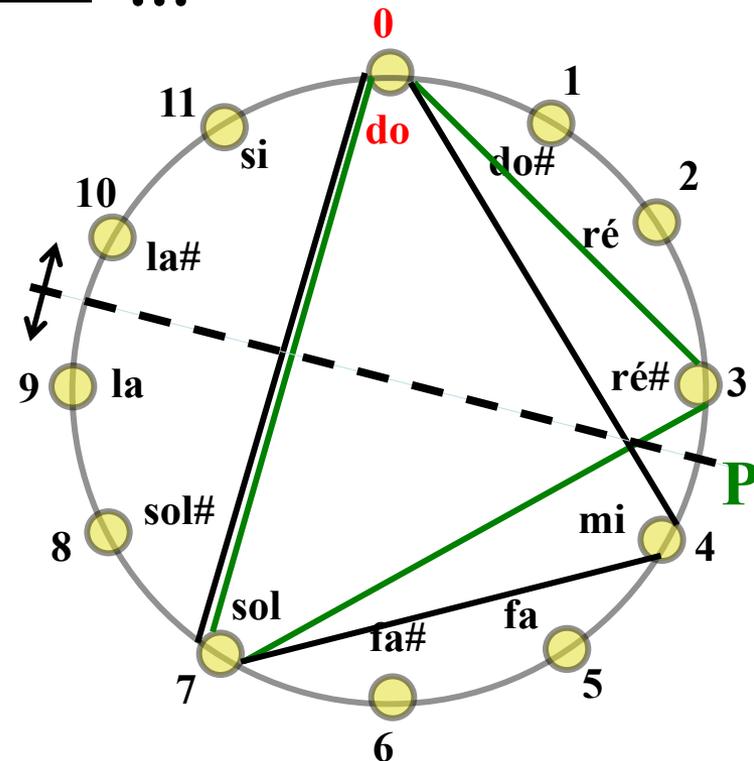
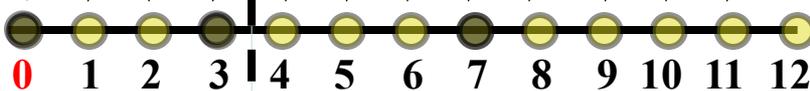
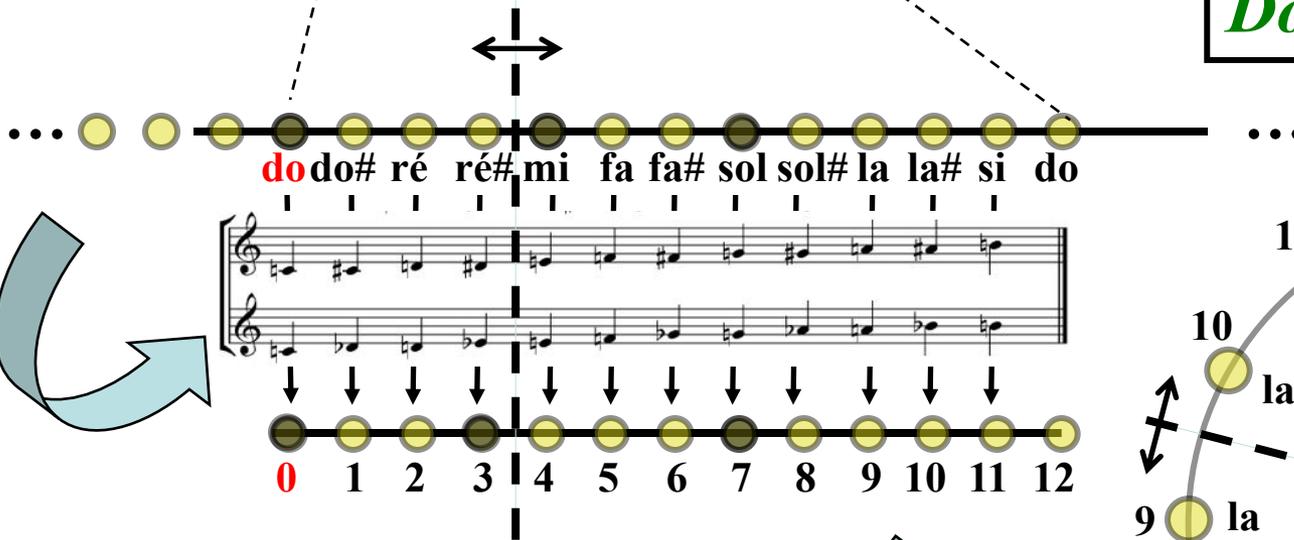
Les inversions sont des symétries axiales



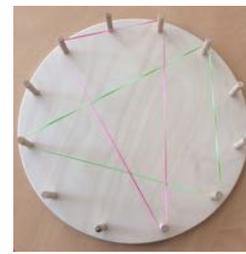
P comme **parallèle**

Do maj = {0,4,7}

Do min = {0,3,7}



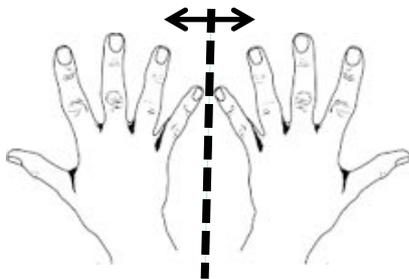
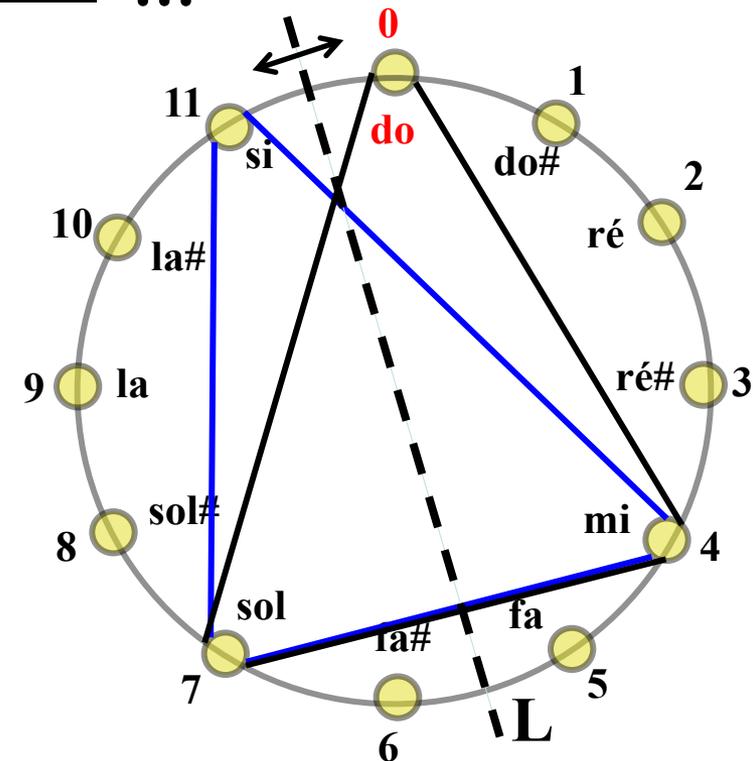
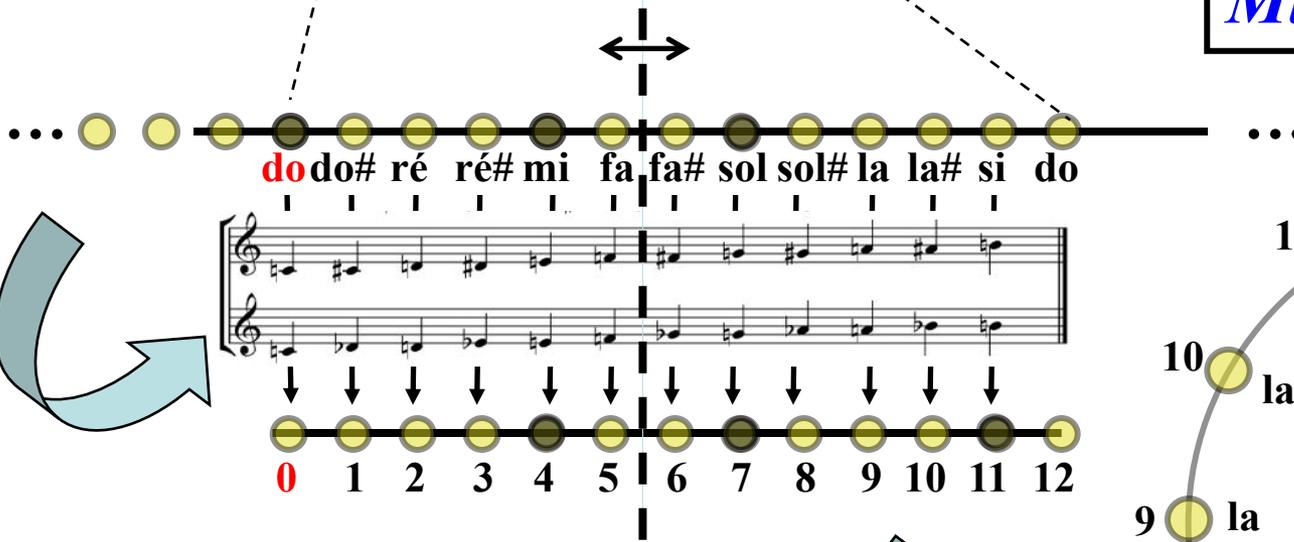
Les inversions sont des symétries axiales



L = Leading Tone

Do maj = {0,4,7}

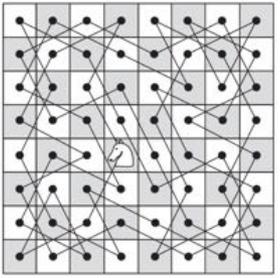
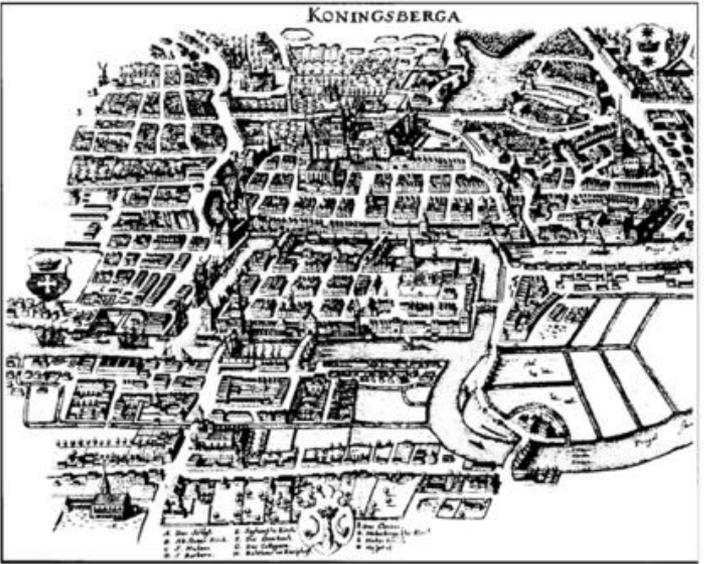
Mi min = {4,7,11}



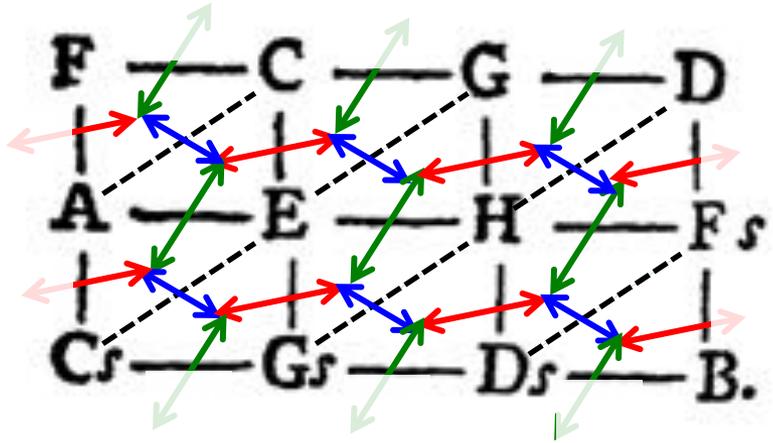
Euler et la naissance de la théorie des graphes



Le Tonnetz (ou nid musical d'abeilles)

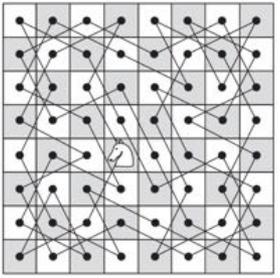
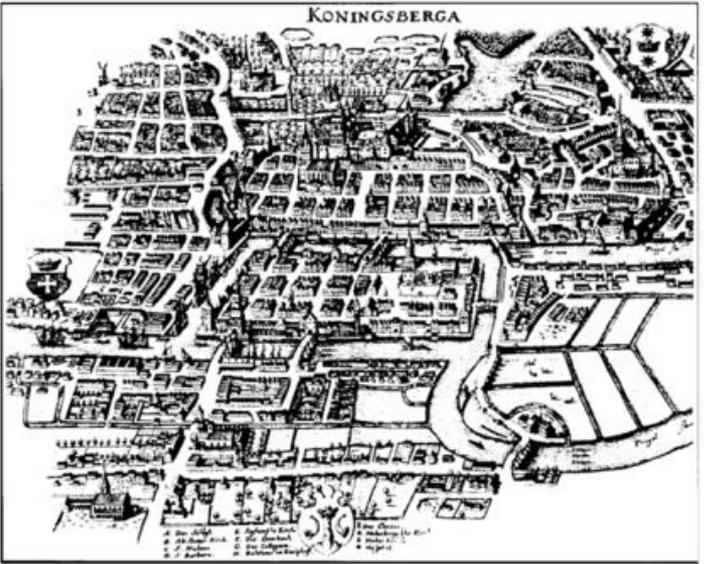
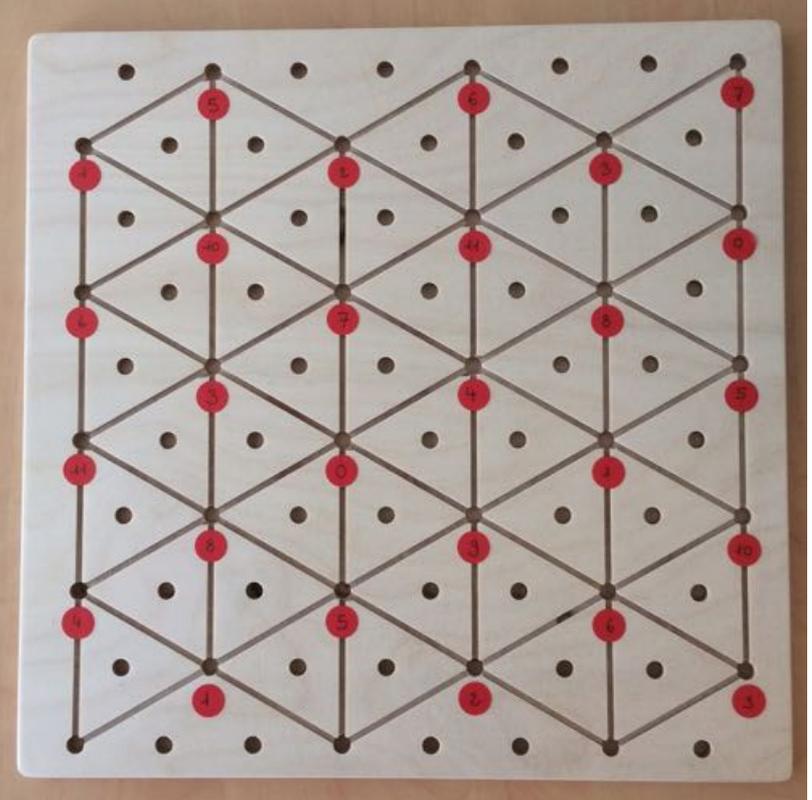


Leonhard Euler

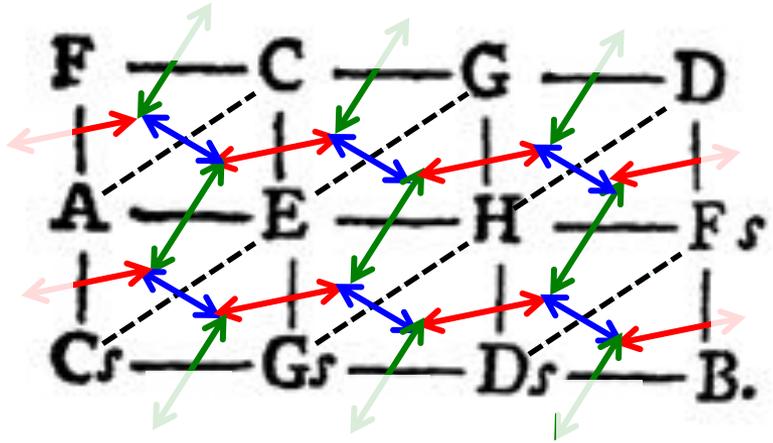


Speculum Musicum (1773)

Le Tonnetz (ou nid musical d'abeilles)



Leonhard Euler

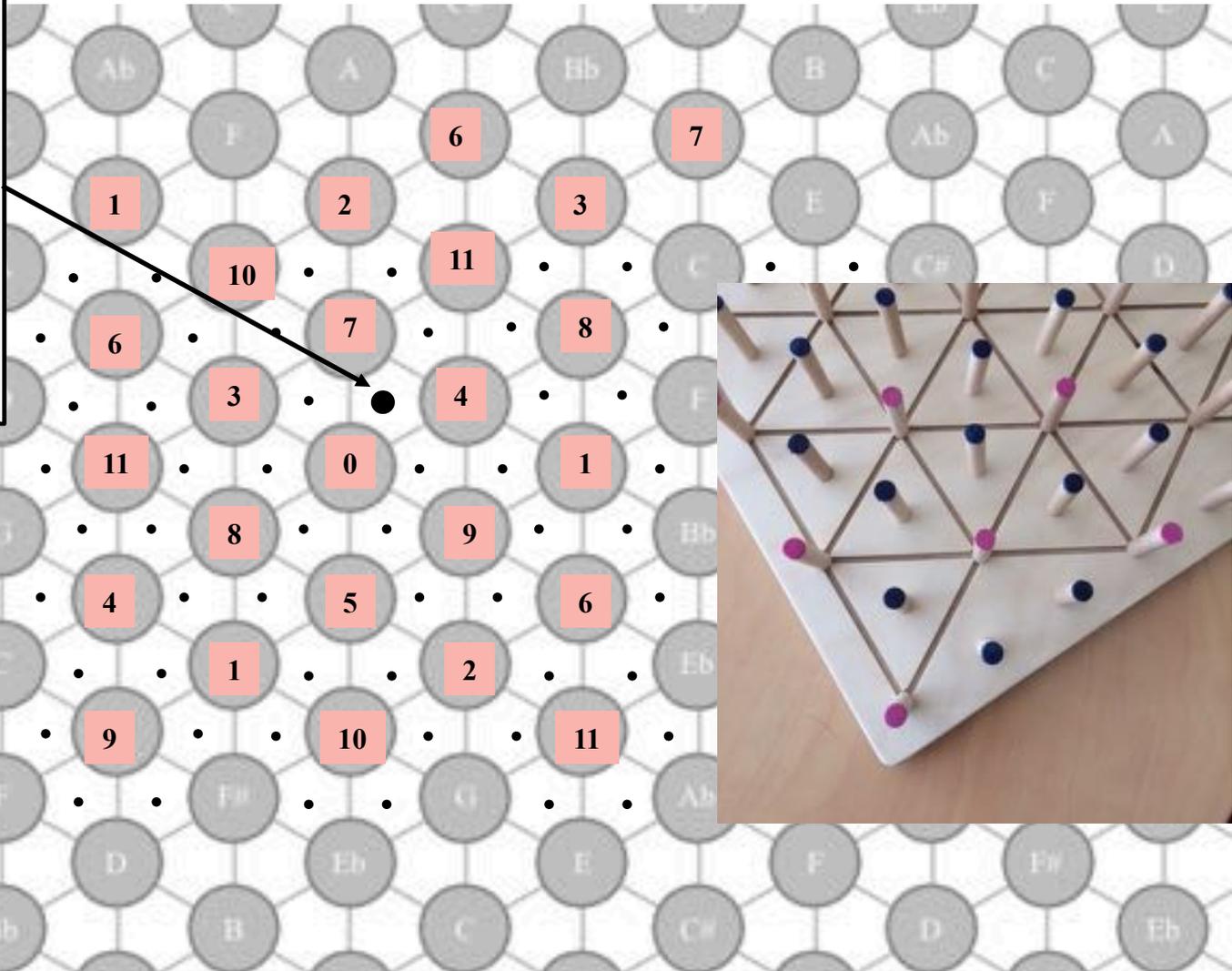
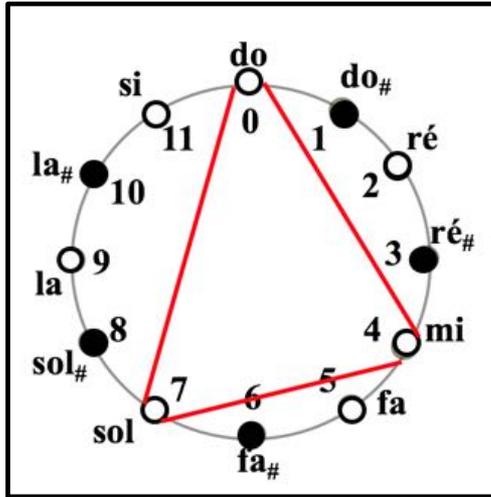


Speculum Musicum (1773)

➔ DEMO

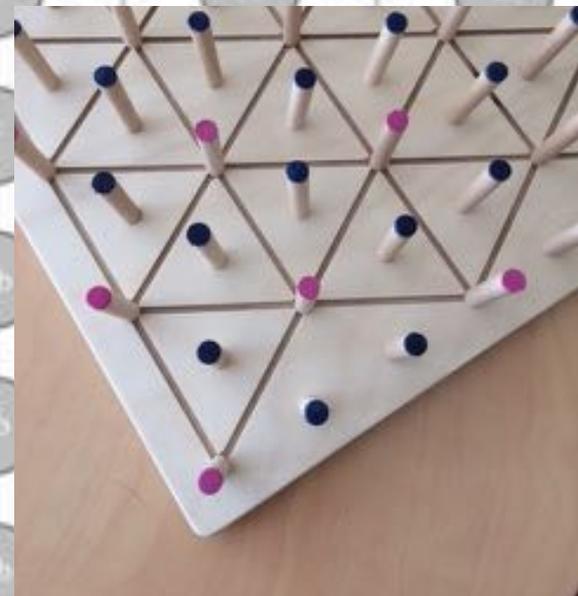
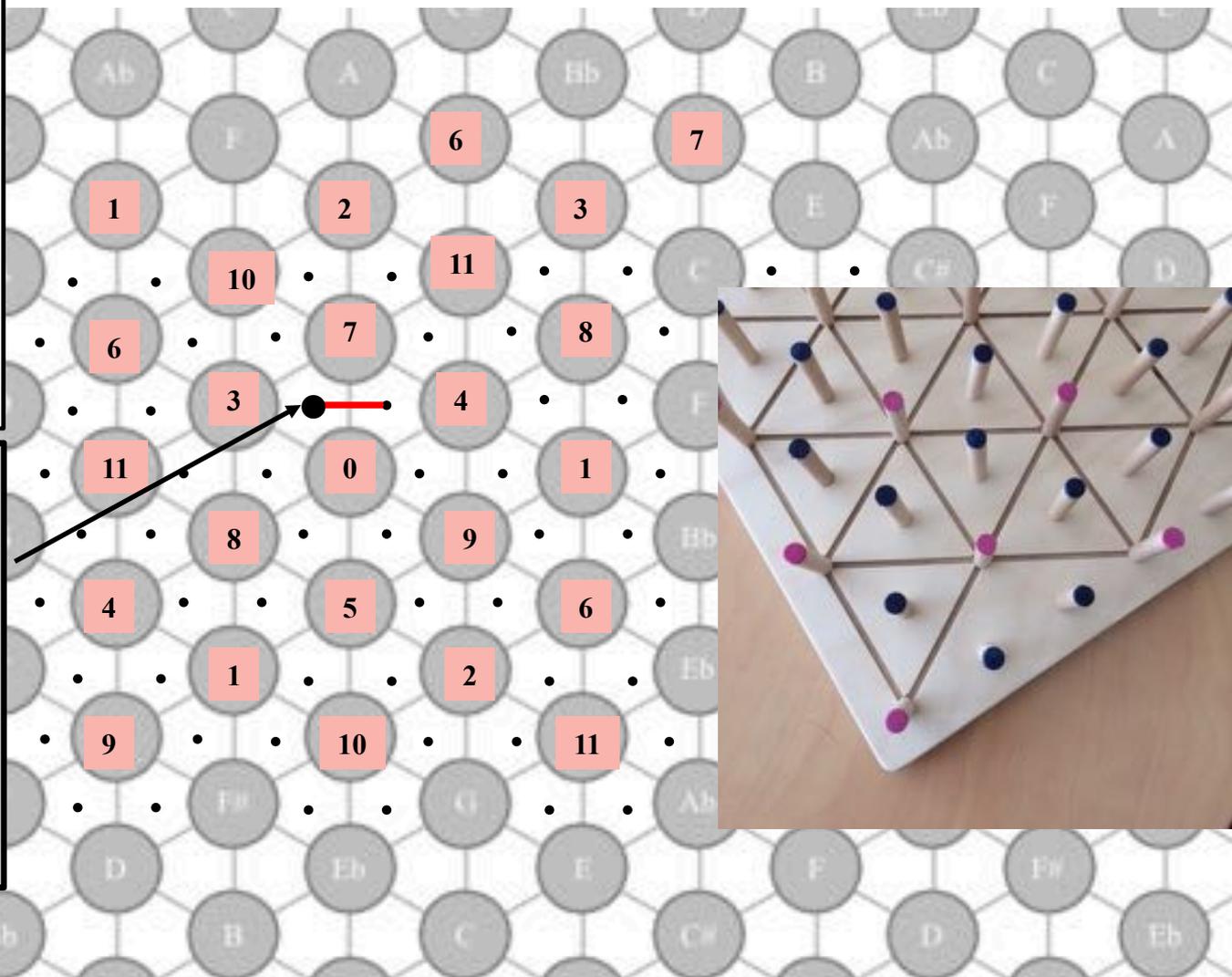
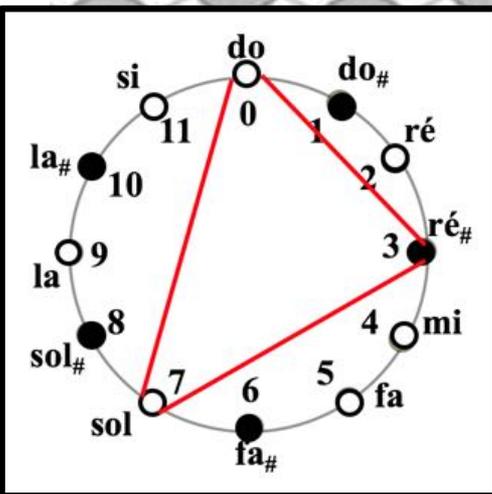
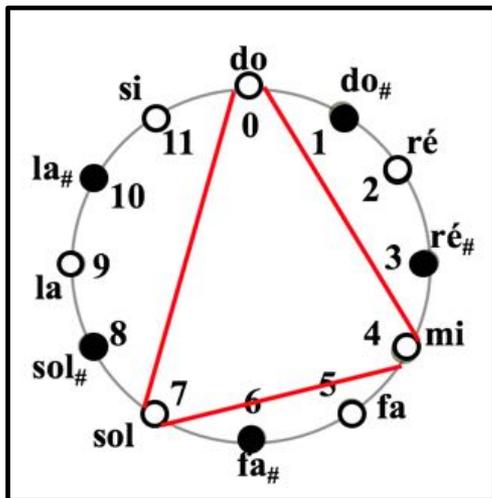
Réponse :

Les bâtons noirs correspondent aux accords (majeurs et mineurs)



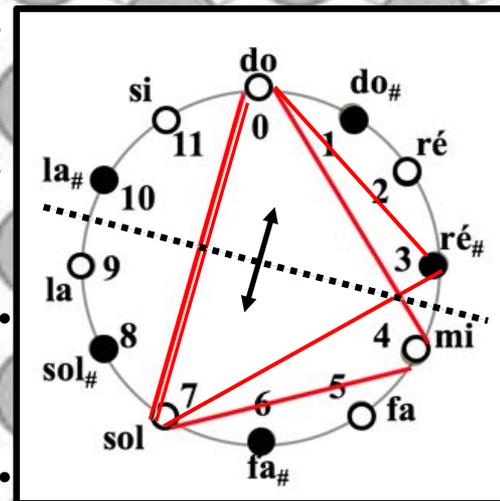
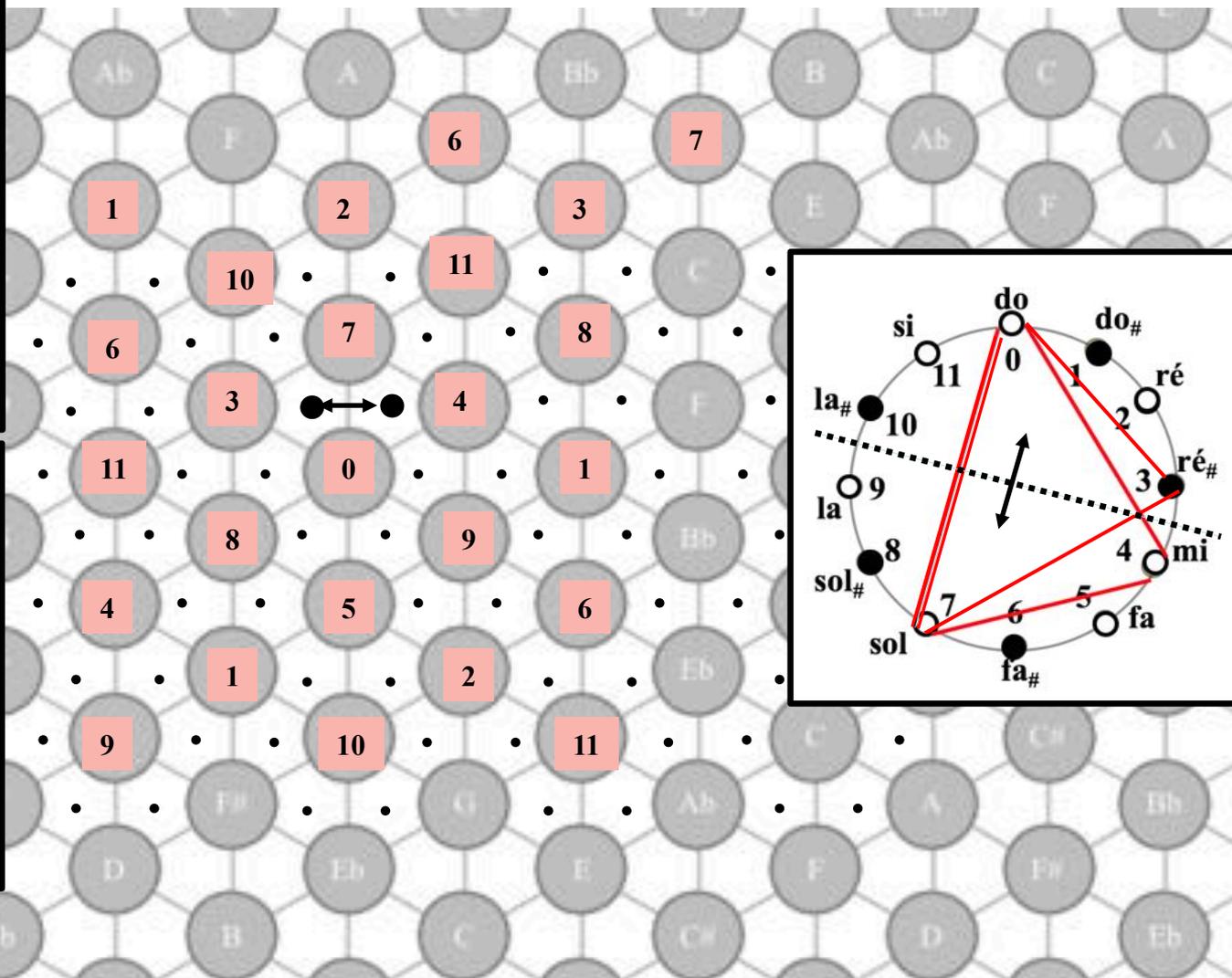
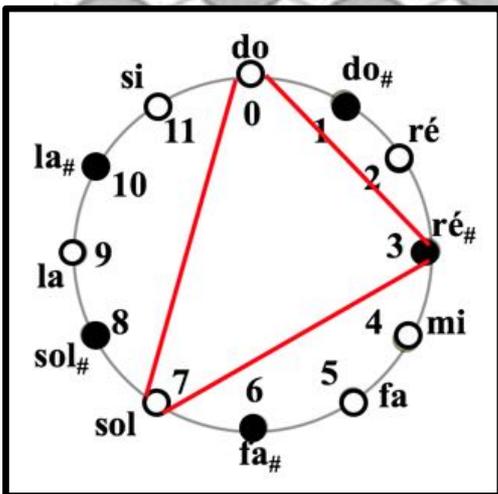
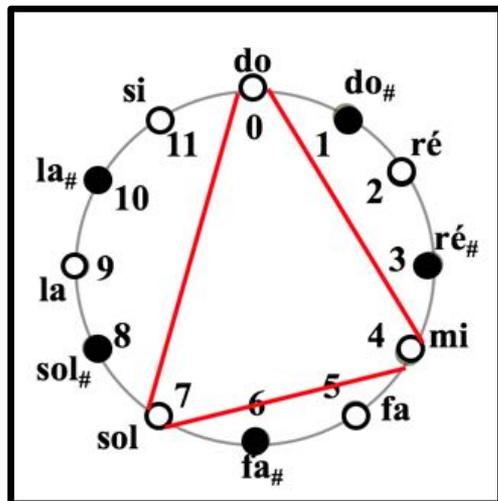
Réponse :

Le symétrique de l'accord majeur c'est l'accord mineur !



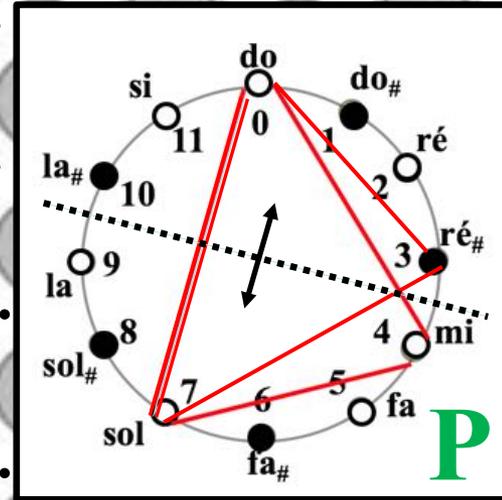
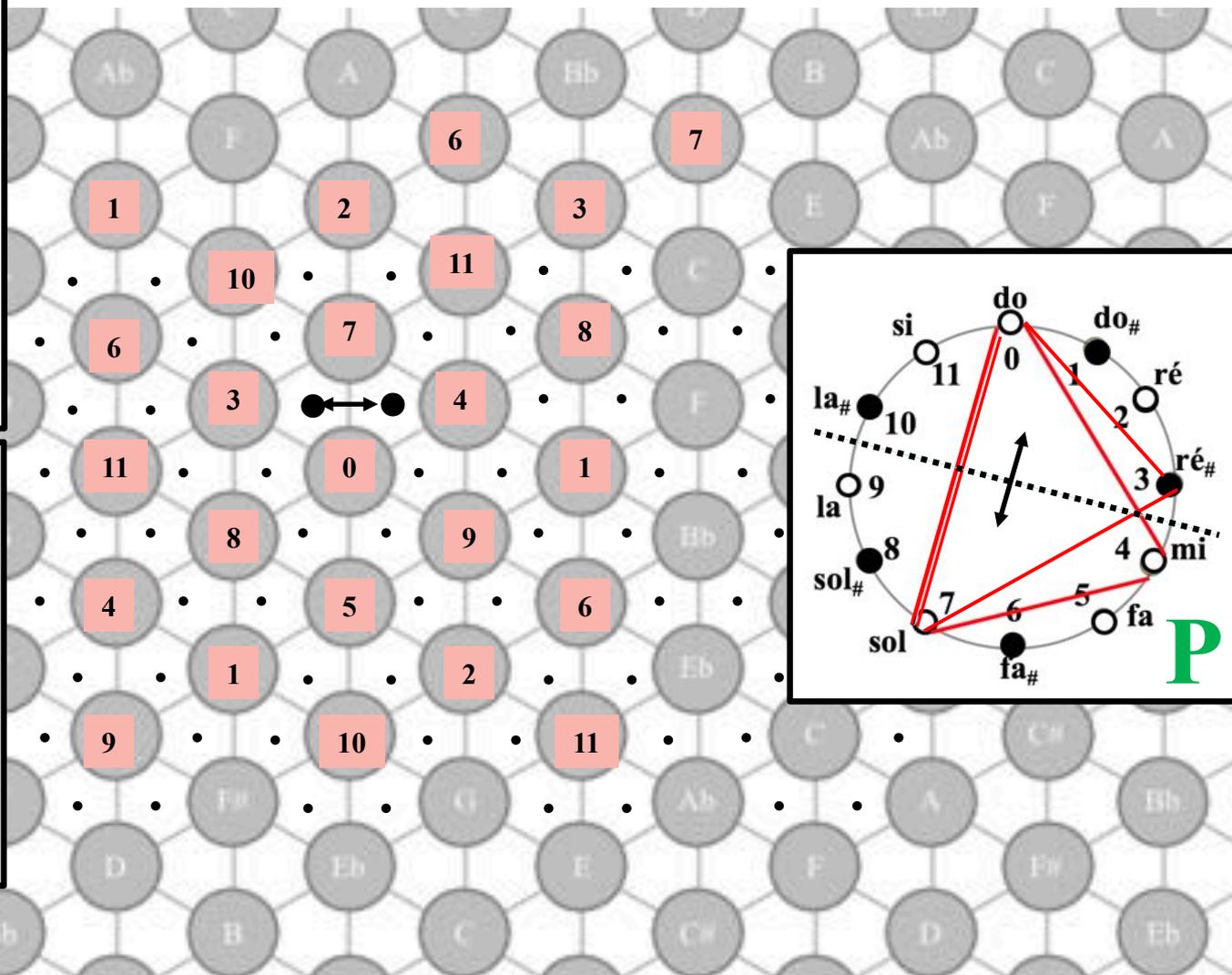
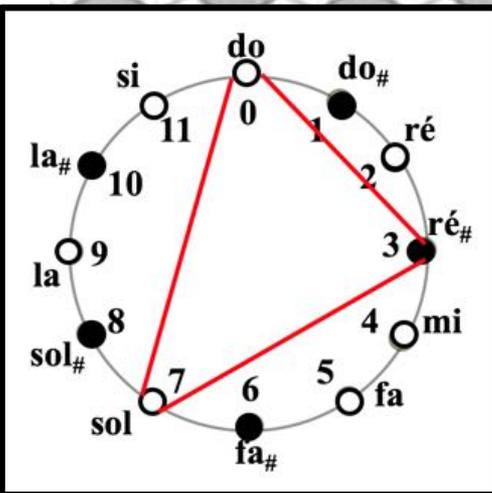
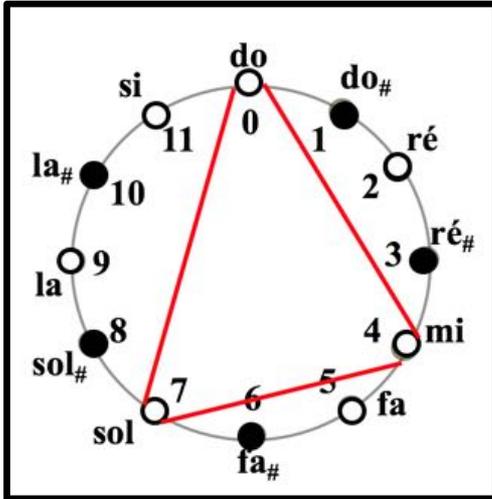
On retrouve la symétrie majeur/mineur

DO majeur ↔ DO mineur



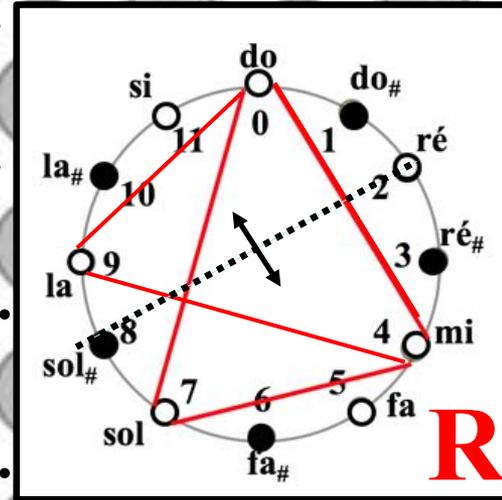
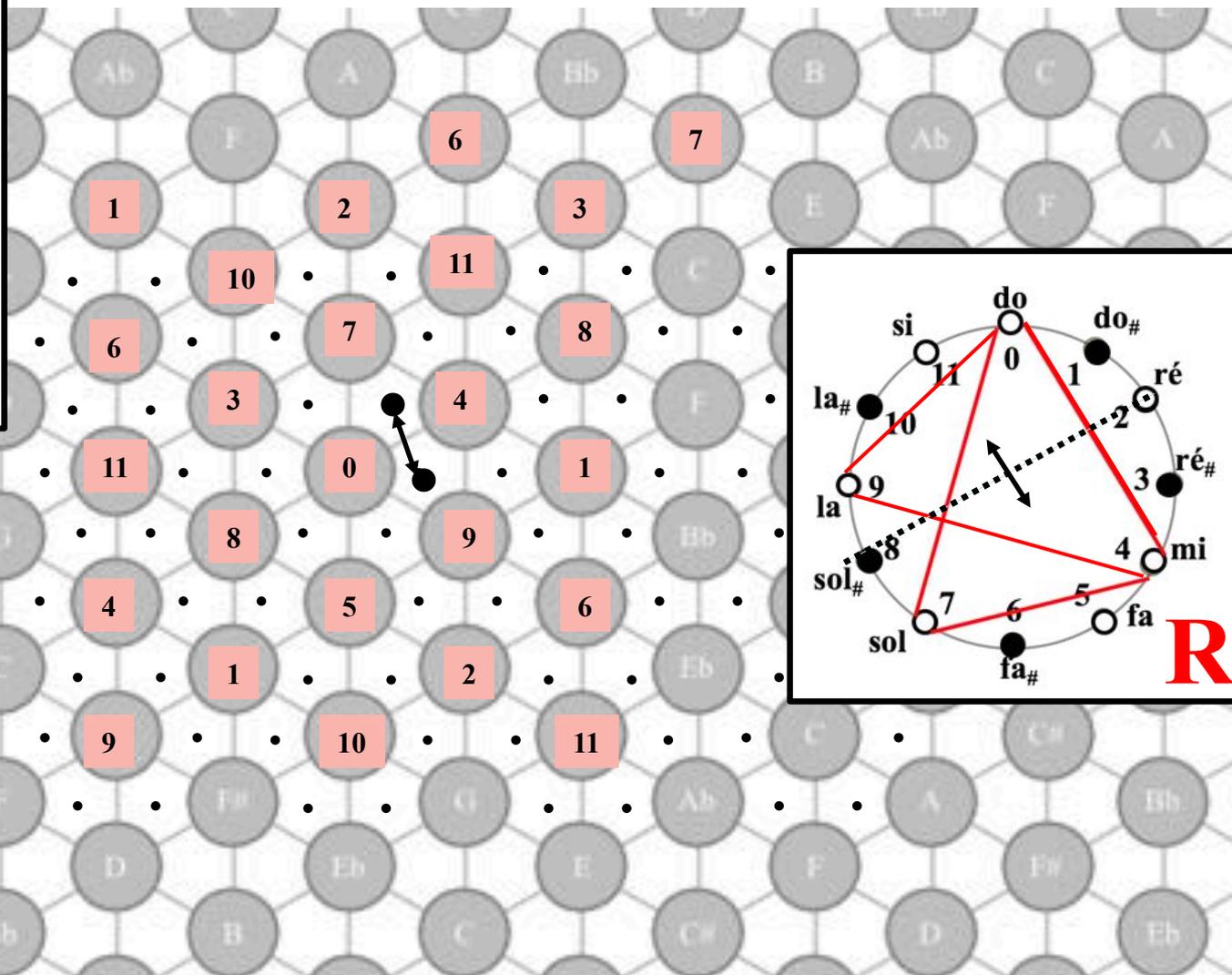
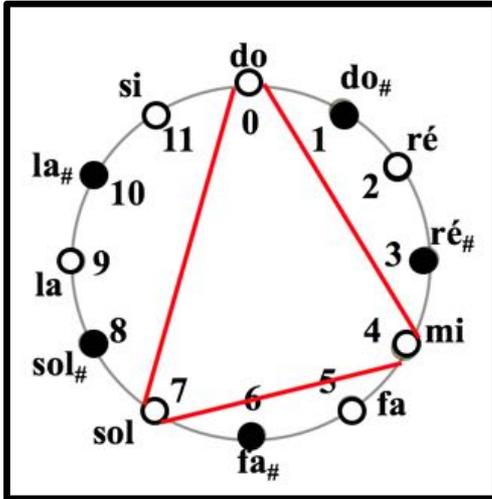
On retrouve la symétrie majeur/mineur

DO majeur ↔ DO mineur



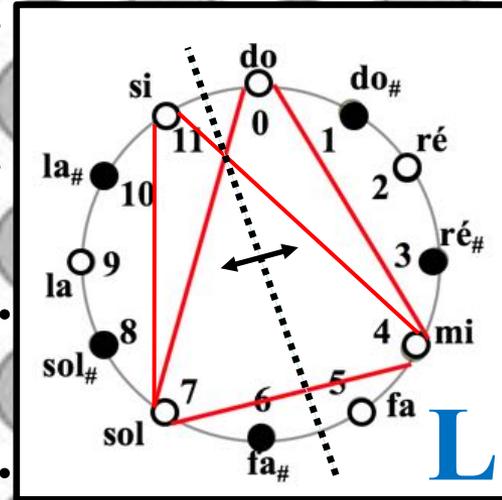
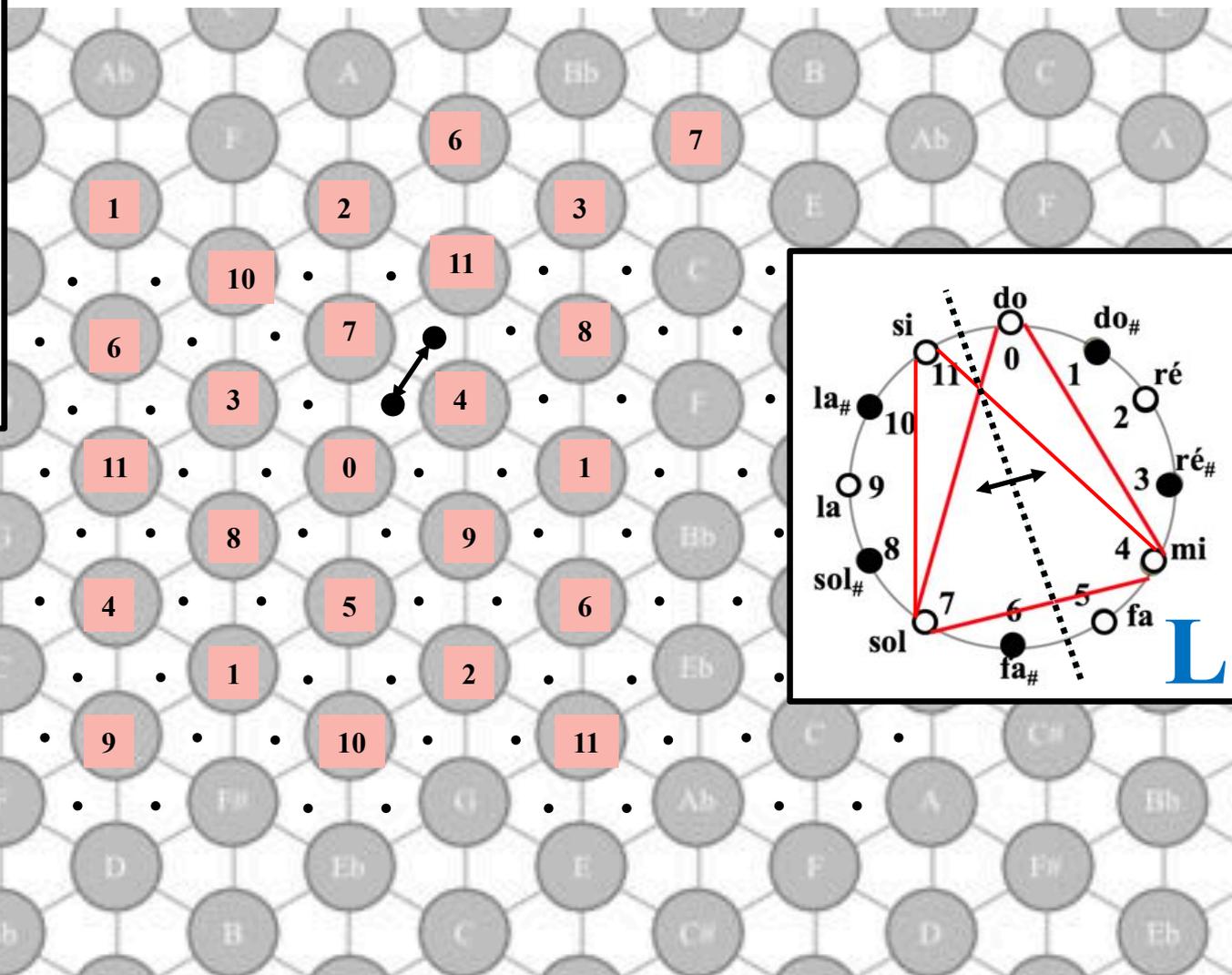
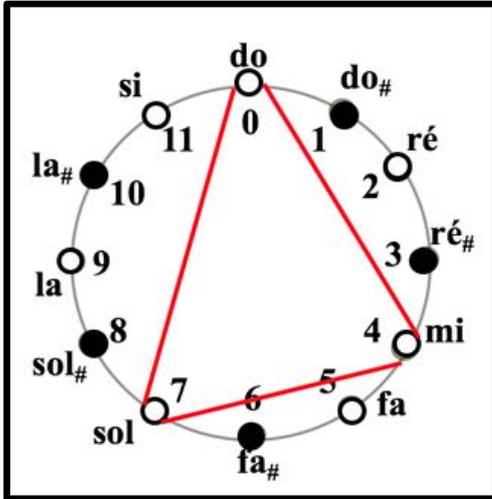
On retrouve la symétrie majeur/mineur

DO majeur ↔ LA mineur



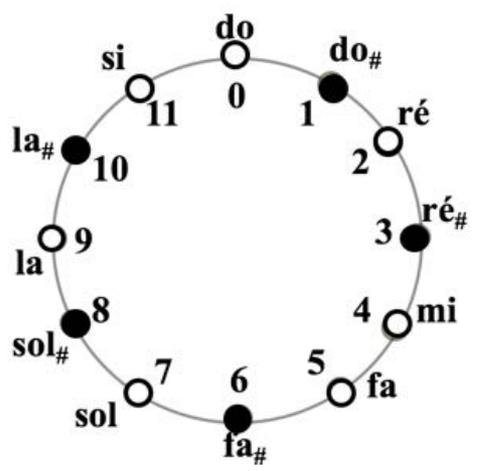
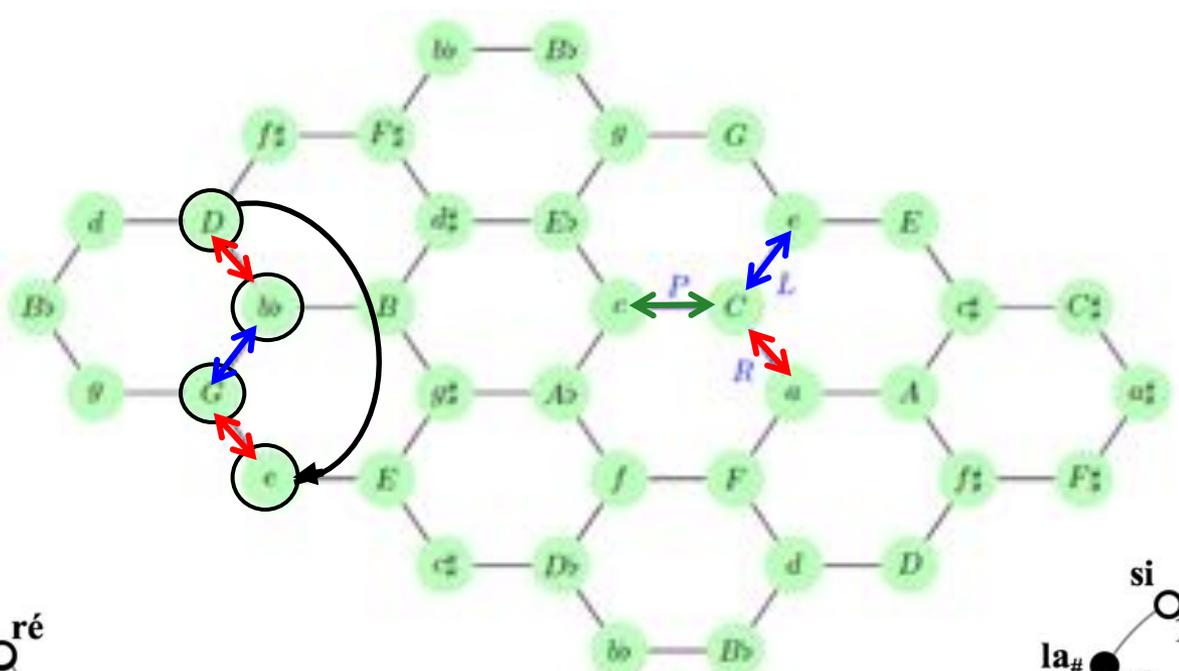
On retrouve la symétrie majeur/mineur

DO majeur ↔ MI mineur



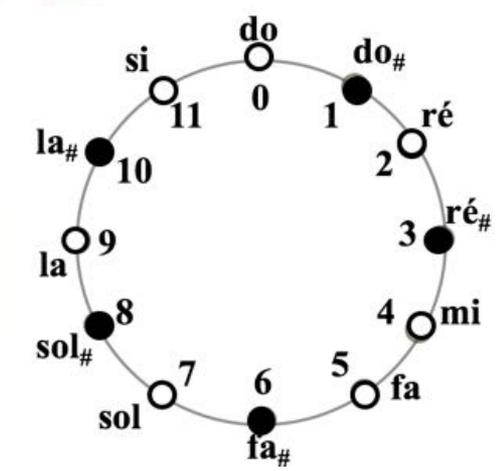


Yann Tiersen



Comptine d'un autre été

Amelie - Large Version



Em \xrightarrow{R} G \xrightarrow{L} Bm \xrightarrow{R} D \xrightarrow{RLR} Em

Les zig-zag du *Nebenverwandt*

IL REGNO DEL TANGO (Paolo Conte)



Non son neanche del paese

ho una valigia di carton

sono vestito, sì in borghese,

ma dentro c'è il bandoneon...

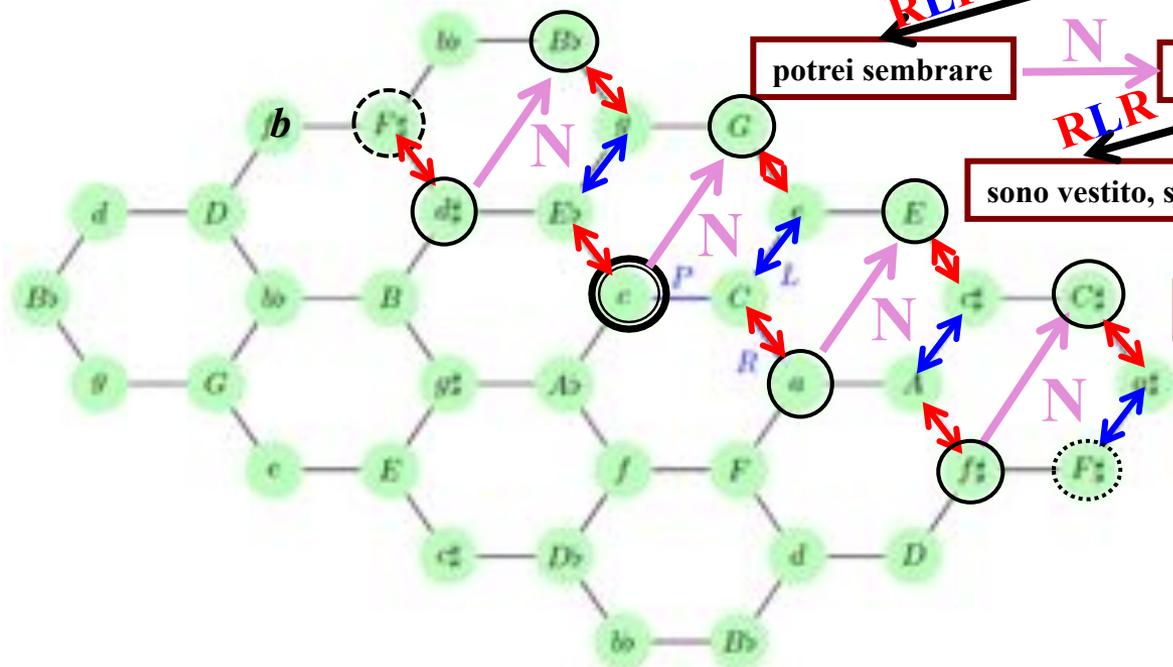
potrei sembrare in borghese,

sono vestito, sì un ragioniere,

anche un geometra potrei,

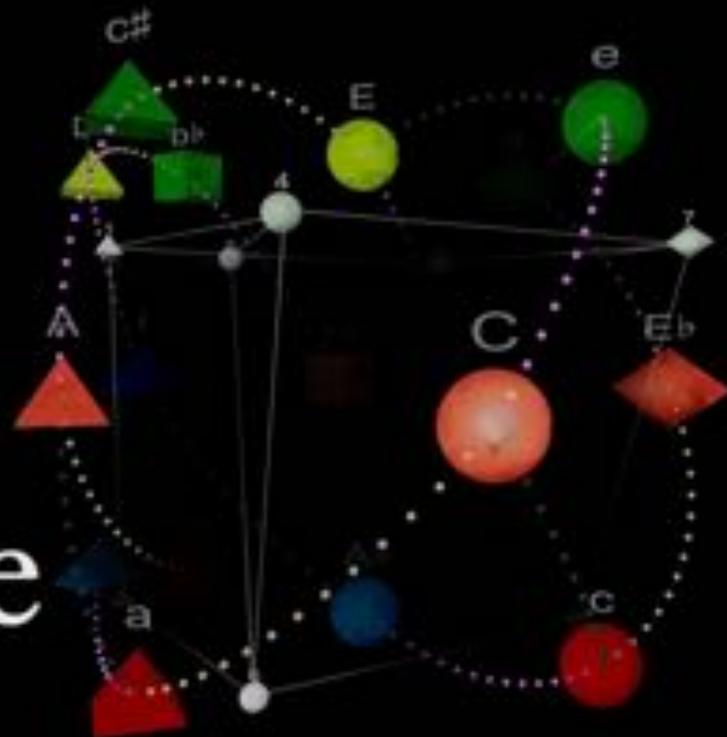
ma un tango sento io gridare

in fondo ai sentimenti miei



Beethoven and the Hypersphere

(and the Tonnetz)



Gilles Baroin 2016
www.MatheMusic.net

→ www.mathemusic.net

Zig-zag et cycles hamiltoniens dans le Tonnetz

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

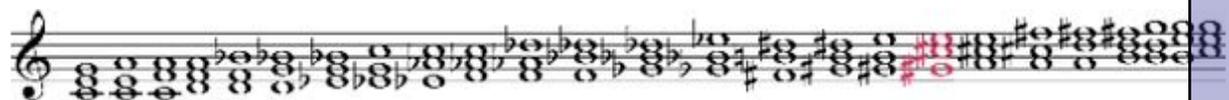
Vers l'îlot d'un petit village

Vers un château d'eau sur la plage

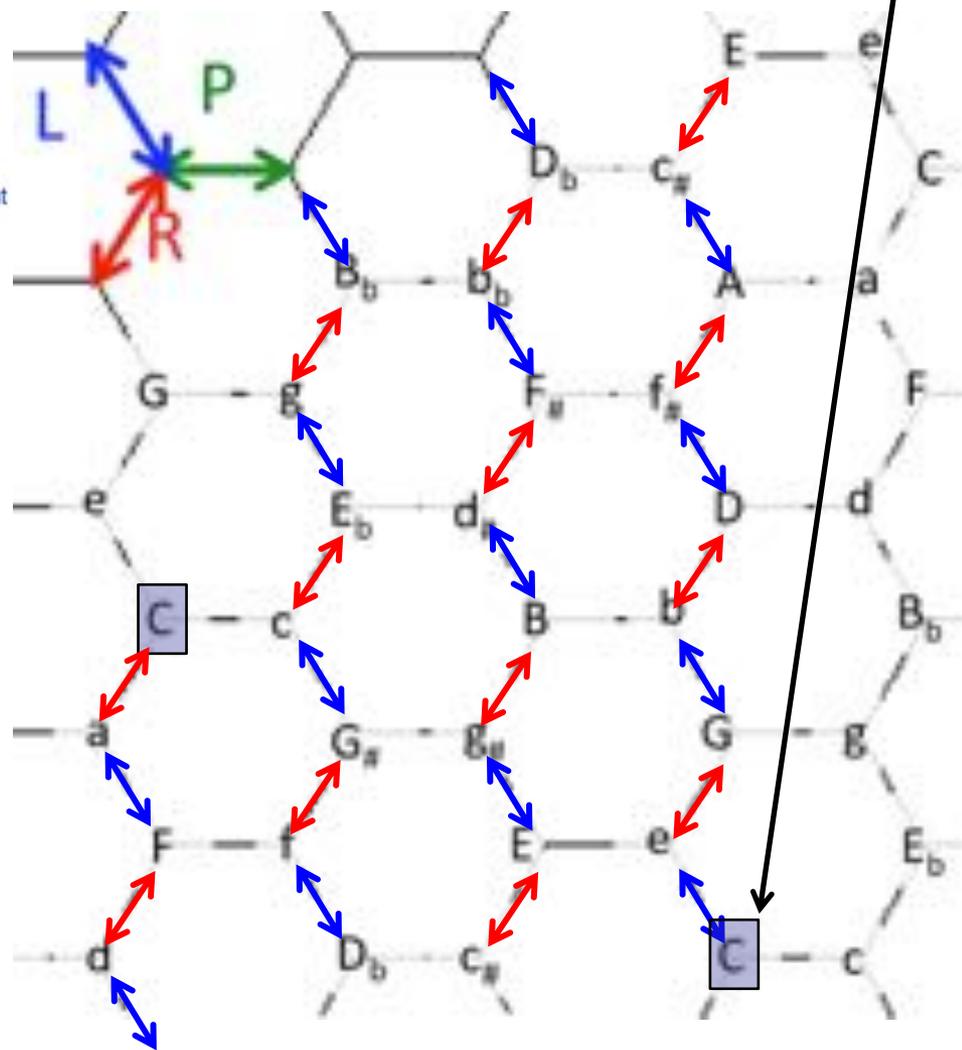
Quand tout s'éteint avant l'orage

Quand se lève le vent du large

Sur le blé vert



← time



CABARET HAMILTONIEN

FABRICE QUÉDY
Formalises dans la musique savante

MORENO ANDREATTI
Mentoratrices appliquées à la musique

POLO PIERRE LAMY
Écriture appliquée aux formes musicales

Alexis - Voix, guitare, écriture
Augustin - Voix, claviers, écriture
Clara - Voix, guitare, écriture
Emilie - Voix, mandoline, écriture
Séverine - Voix, alto, écriture
Thomas - Voix, claviers, écriture

Écrire sous la contrainte...
TACHER DU PAPIER SOUS
L'OBLIGATION DE FAIRE
QUELQUE CHOSE...

SALIR DU BOIS CONDITIONNÉ
AVEC LE DEVOIR MORAL DE
TRANSFORMER UN OBJET
INDEFINI...

SAMEDI 27 FÉVRIER 2016 À 11H
AMPHI PARIS SCIENCE ET LETTRES
22 rue de St-Louis
75005 Paris

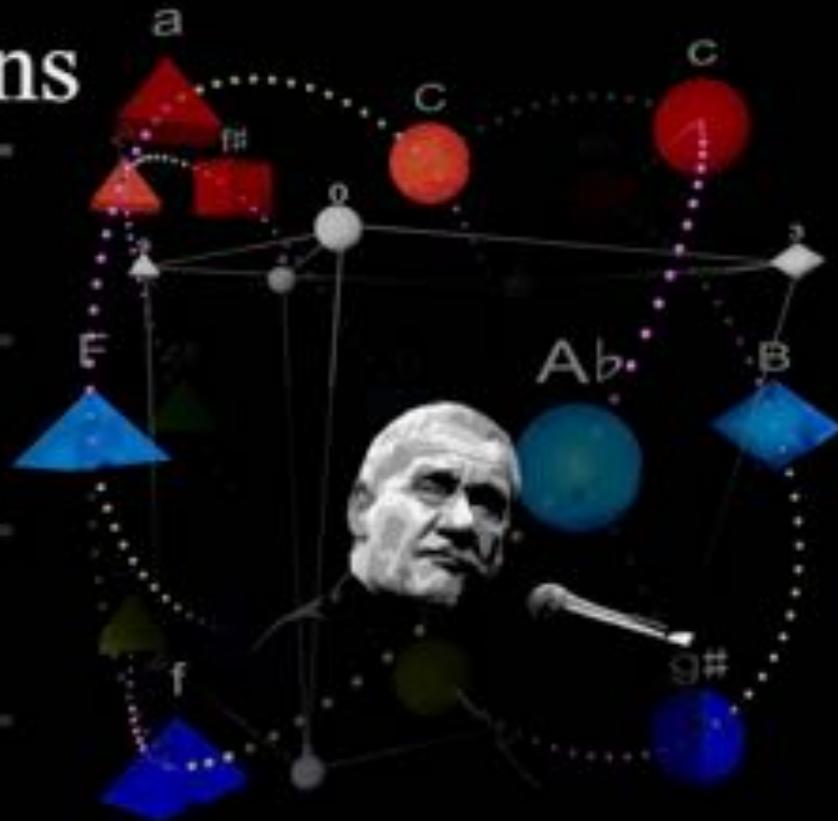
ENTRÉE LIBRE

PSL*
PARIS SCIENCE ET LETTRES

Harmonic Progressions

In Paolo Conte

Madeleine



Supervision Moreno Andreatta
Modelisation Gilles Baroin 2016

www.mathemusic.net



Gilles Baroin

La sera non è più la tua canzone : chanson hamiltonienne ‘redondante’

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.

*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 .*

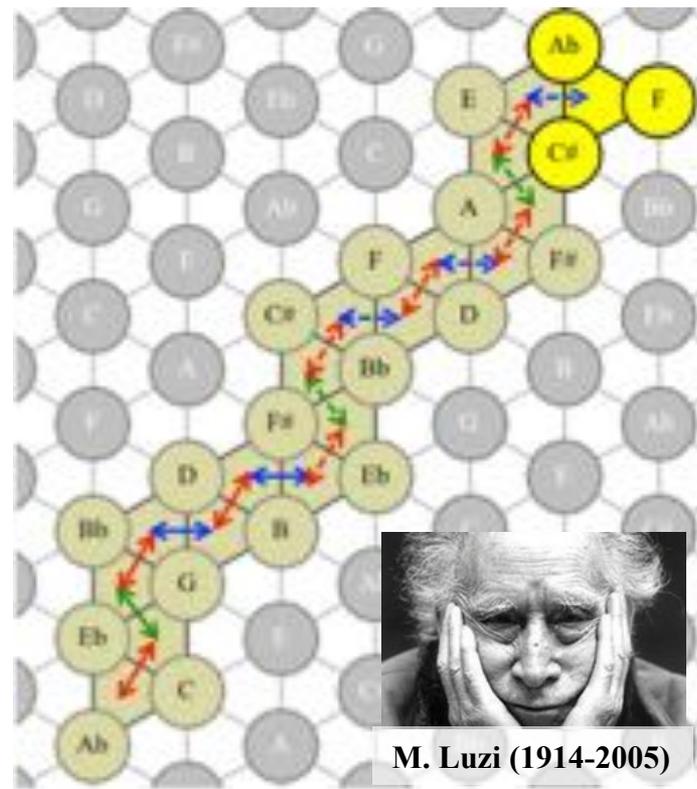
*Tombé est plus qu'un signe de la vie,
tu te reposes, du voyage tu es revenue
à l'intérieur de toi même, tu es
descendue dans cette
pure substance qui est si tienne,
si éloignée
dans le silence de l'être, achevée.*

*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)

Musique : M. Andreatta
Arrangements et mixage : M. Bergomi &
S. Geravini
(Perfect Music Production)
Mastering : A. Cutolo (Massive Arts
Studio, Milan)

min. 1'19"



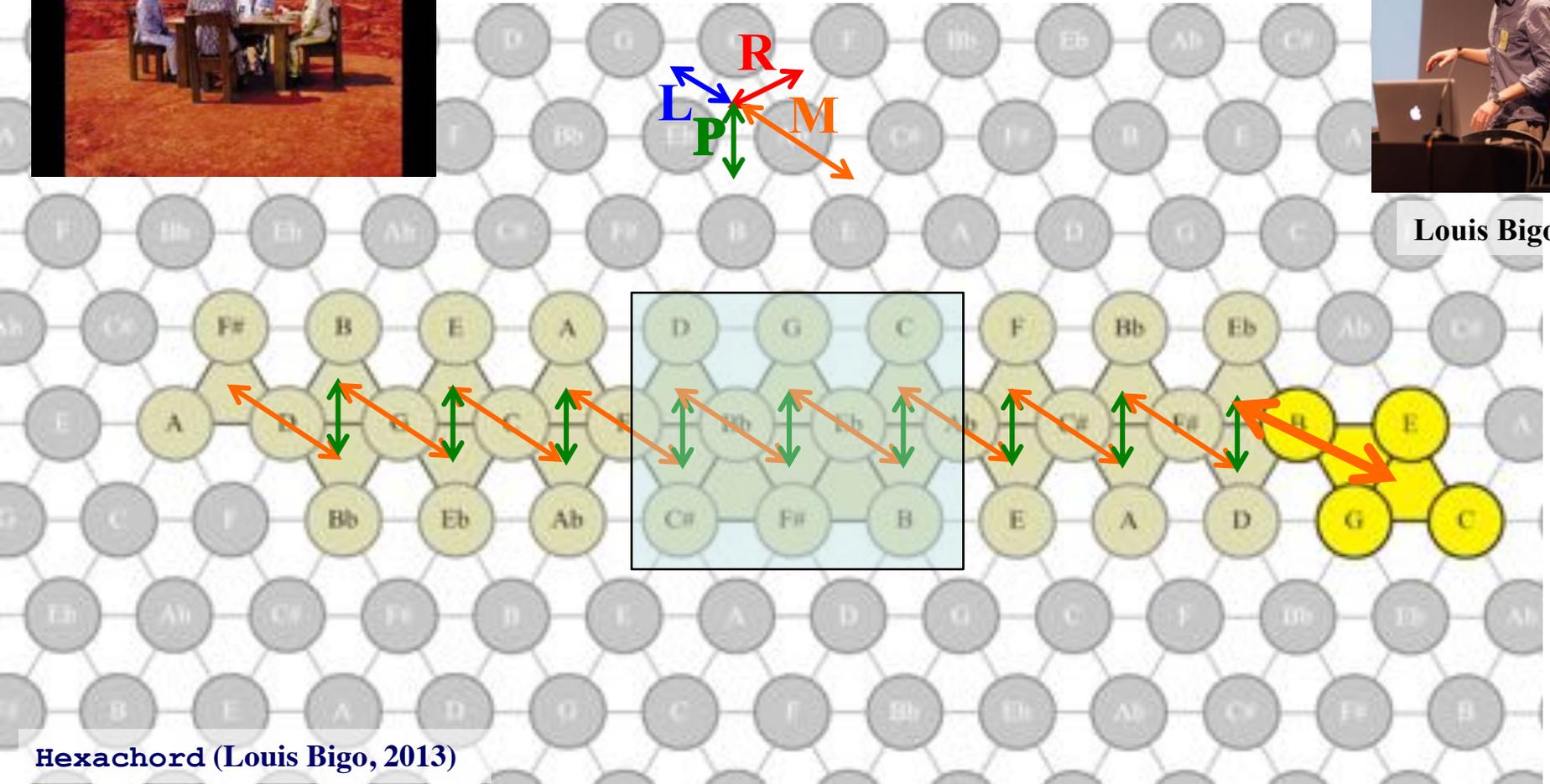
Symétries et procédés algorithmiques chez *Muse*

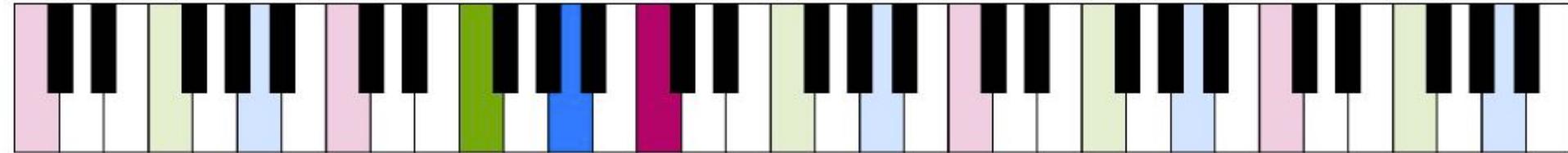


“Take a bow” (*Black Holes and Revelations*, 2006)



Louis Bigo





L'environnement web Tonnetz

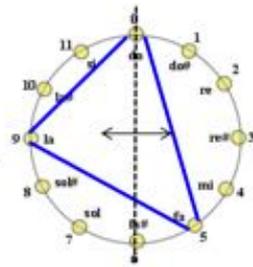
(conçu et développé par C. Guichaoua & M. Andreatta / Projet SMIR, USIAS/Université de Strasbourg)

➔ <https://guichaoua.gitlab.io/web-hexachord/>

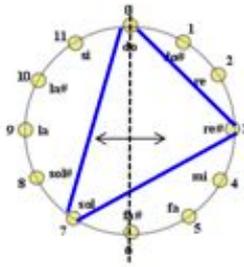
L'harmonie négative ou la dualité majeur/mineur



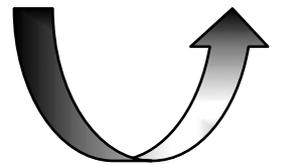
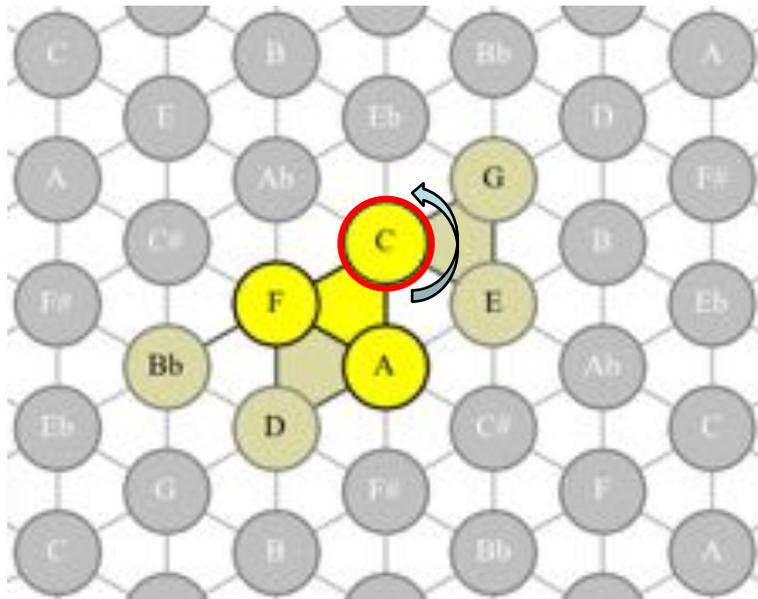
Accord
majeur



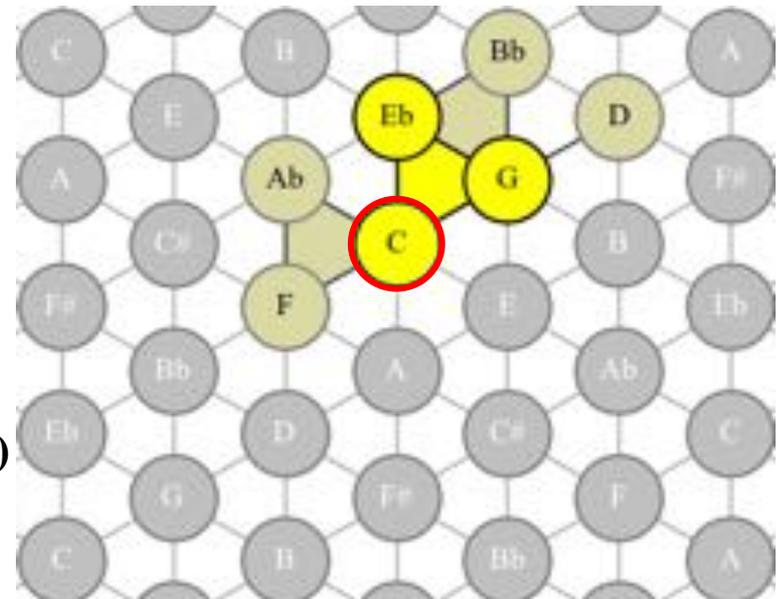
inversion



Accord
majeur



Rotation
(autour du do)





2019
année des mathématiques
2020

Math'n Pop

Conférence
concert

<https://www.mathnpop.com/>

Merci
et...

...à cet
après-
midi
avec
Math'n
Pop !

