



THE  
BOOK IS  
NOW  
AVAILABLE!

# SOUND5

TIMBRE

TOMMASO ROSATI  
SOUND ART

## PLAY WITH SOUND

MANUAL FOR ELECTRONIC  
MUSICIANS AND OTHER SOUND  
EXPLORERS



TOMMASO ROSATI  
TIMOTHY HSU

A Focal Press Book



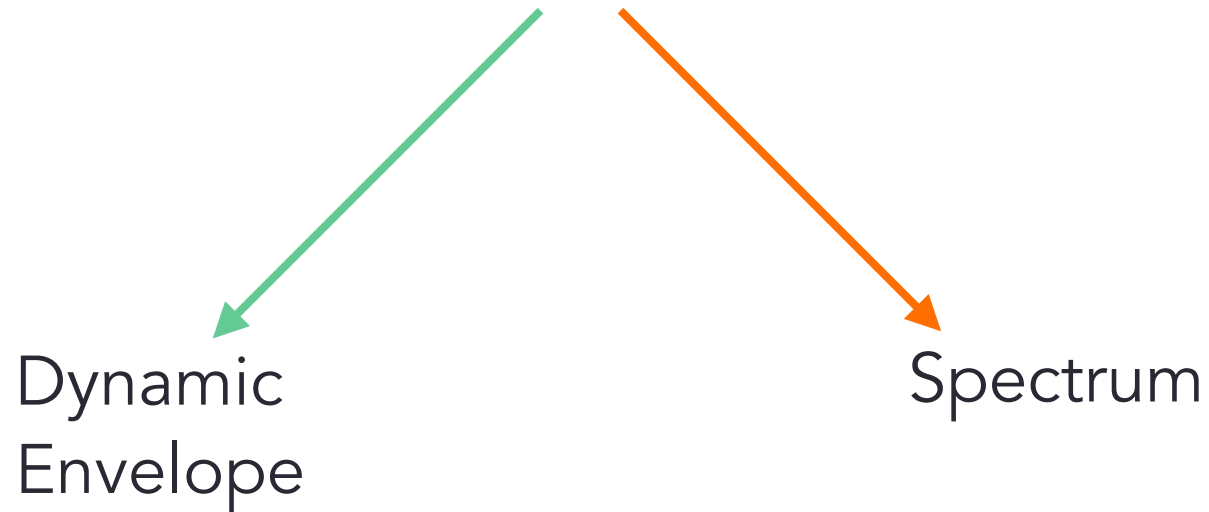
# Timbre

Timbre is the characteristic of sound that makes one instrument distinguishable from another, even if they play the same note at the same dynamic level.

It's not measurable as frequency, amplitude, or phase but needs multiple factors to describe it.

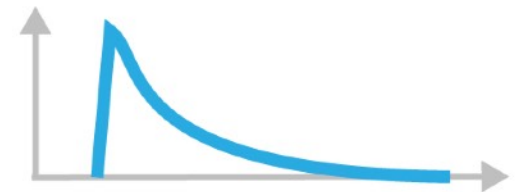


The **Timbre** is formed mainly  
by two aspects



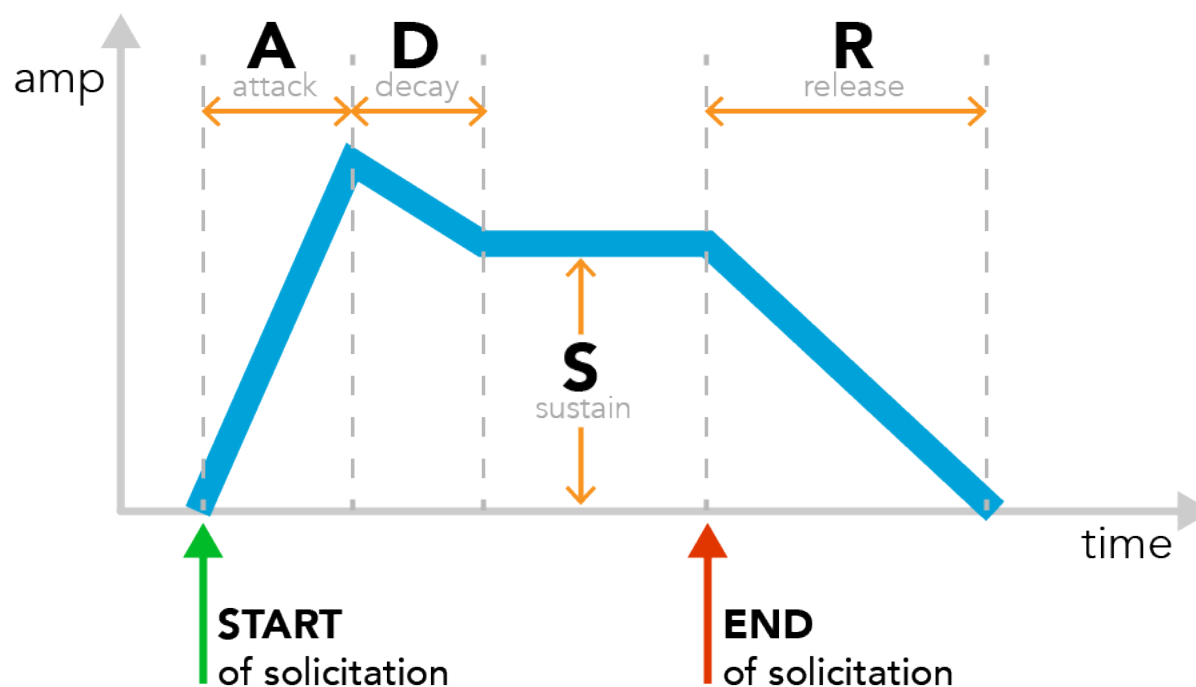
# Dynamic envelope

The **dynamic envelope** is a detailed look at the dynamics of a note played by an instrument, describing the amplitude of a note from the moment it is excited to when the note fades away to nothing.



# Dynamic envelope

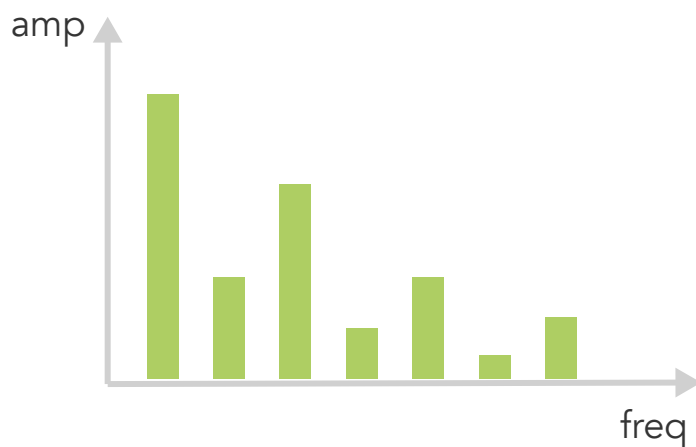
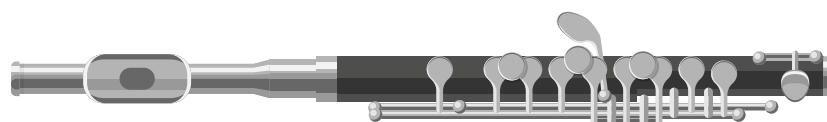
The dynamic envelope is broken into four time segments: the Attack, Decay, Sustain, Release. This type of dynamic envelope is known generally as **ADSR**.



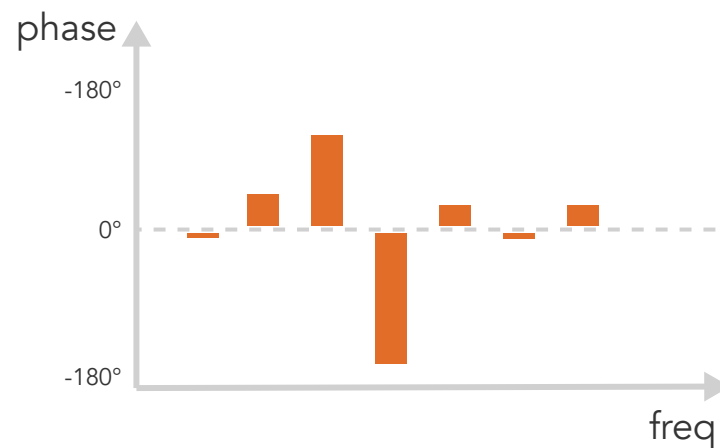
# Spectrum

In nature, every sound we hear, even the most complex, can be thought of as the sum of simple sine wave components of varying frequencies (Fourier Theorem).

By “photographing” an instant of sound, the spectrum can be represented with an **amplitude spectrum** and with a **phase spectrum**



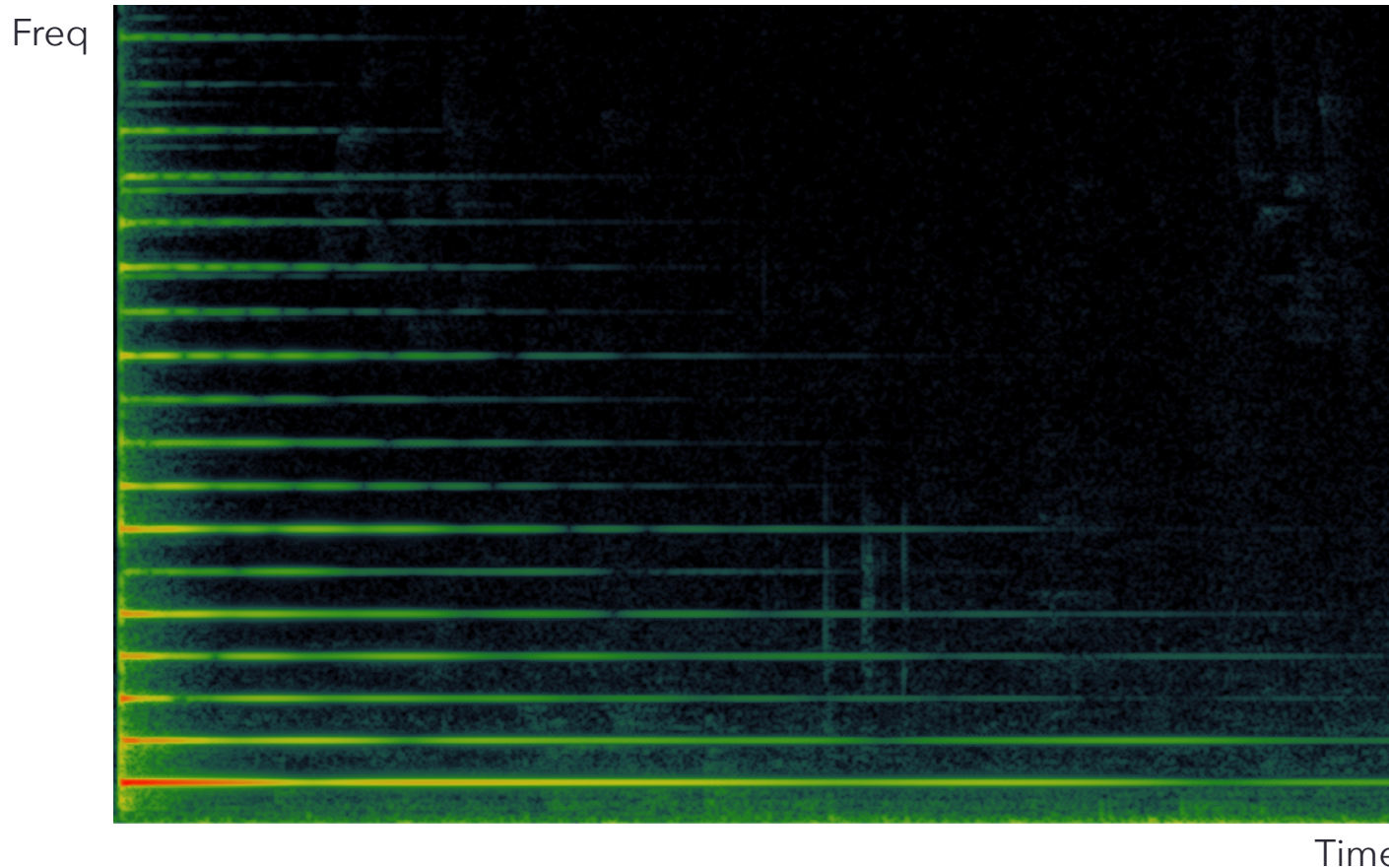
**AMPLITUDE SPECTRUM**



**PHASE SPECTRUM**

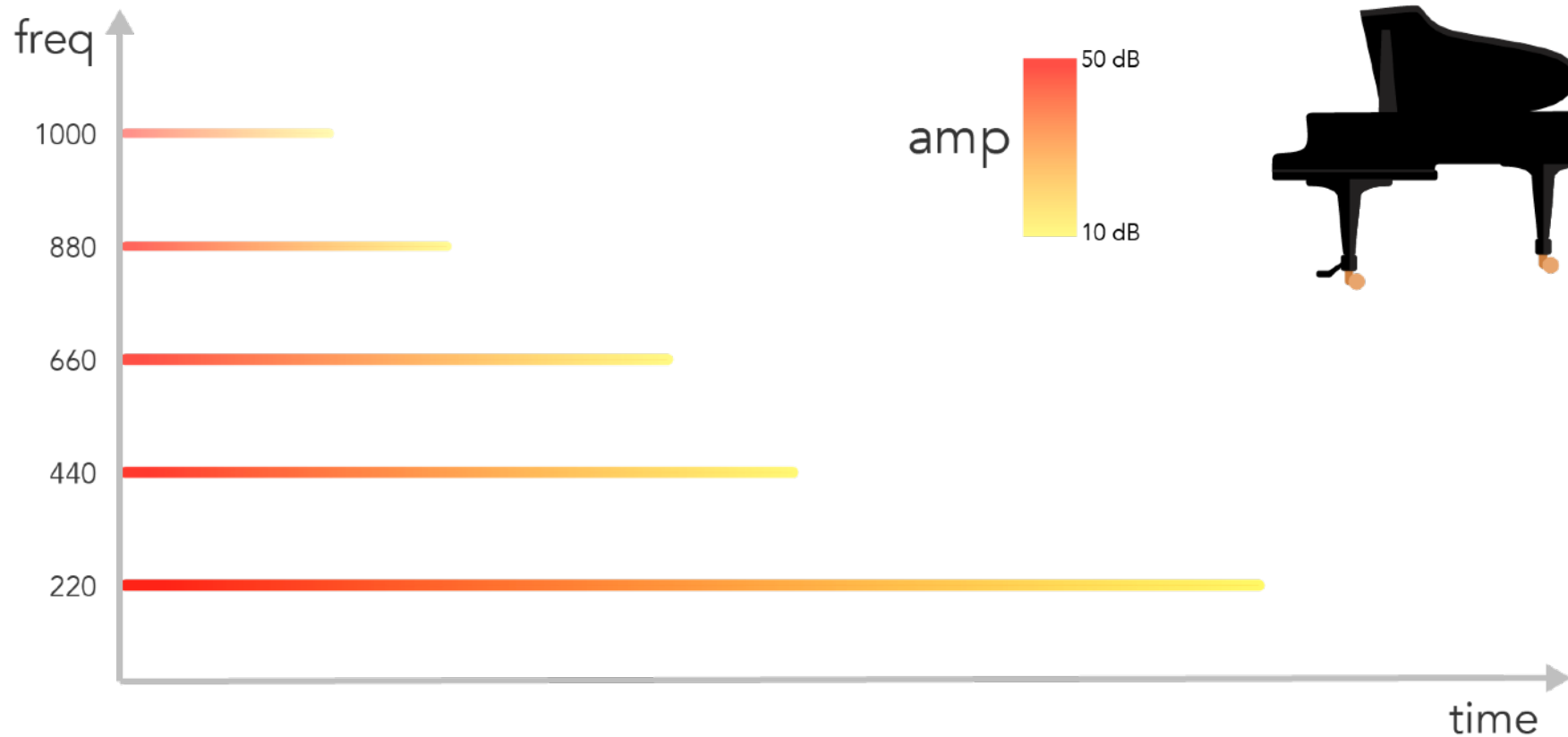
The timbre of an instrument cannot actually be reduced to a static “photograph” of the spectrum in an instant but is, more properly, a series of consecutive “photographs” of the spectrum itself.

In a **spectrogram**, time is depicted on the X-axis, the Y-axis shows frequency, and the color (more or less intense) describes the amplitude of that given partial.

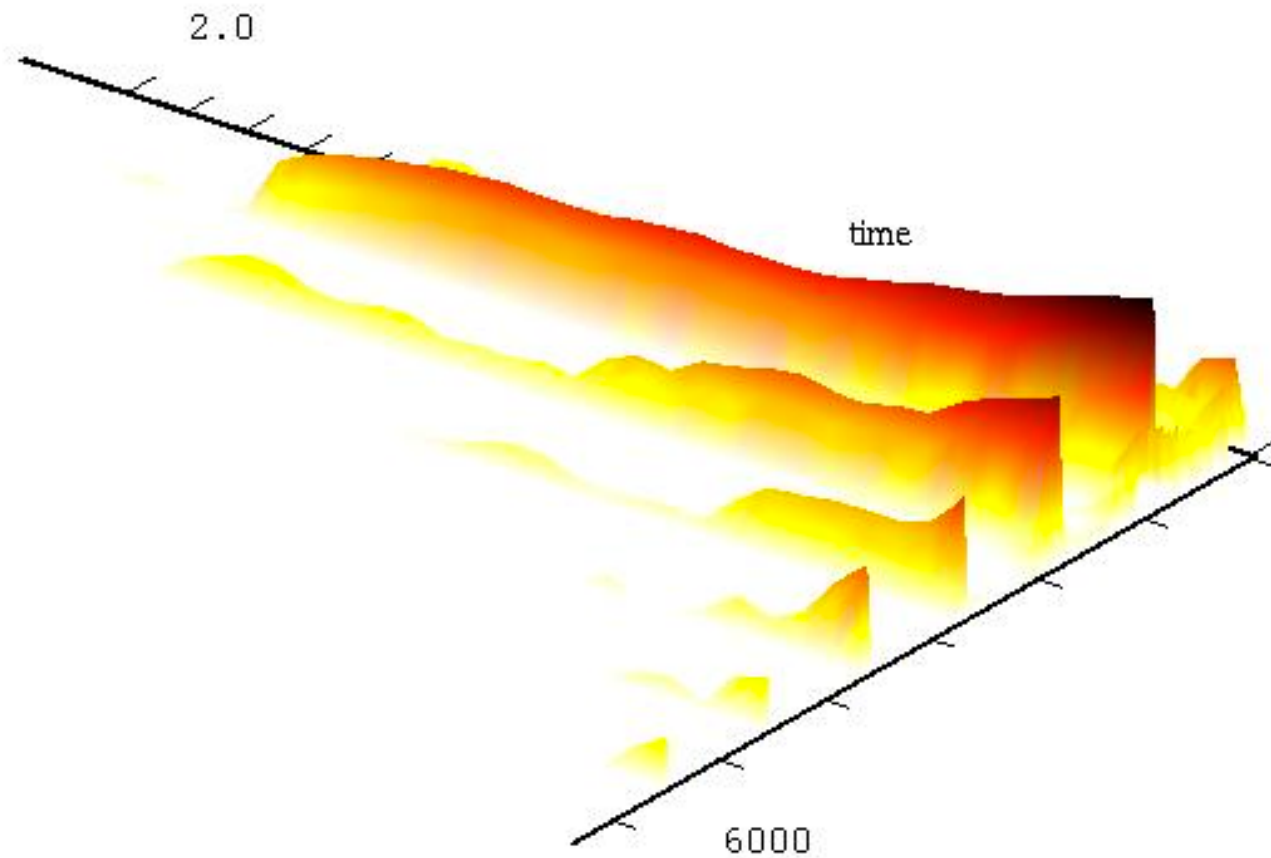


# Spectrogram

a pianoforte note

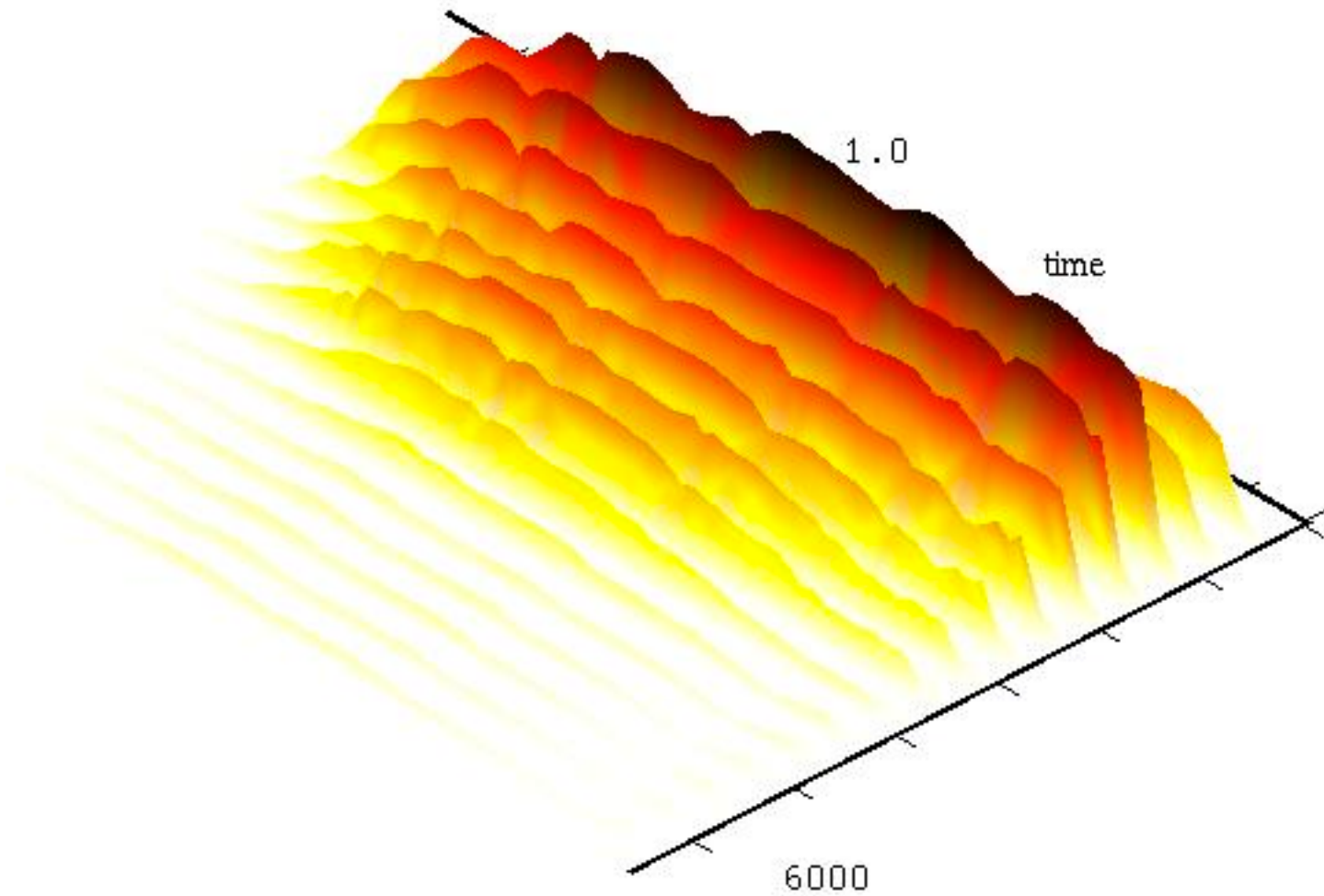


# 3D Spectrogram or Waterfall plot a pianoforte note



# 3D Spectrogram

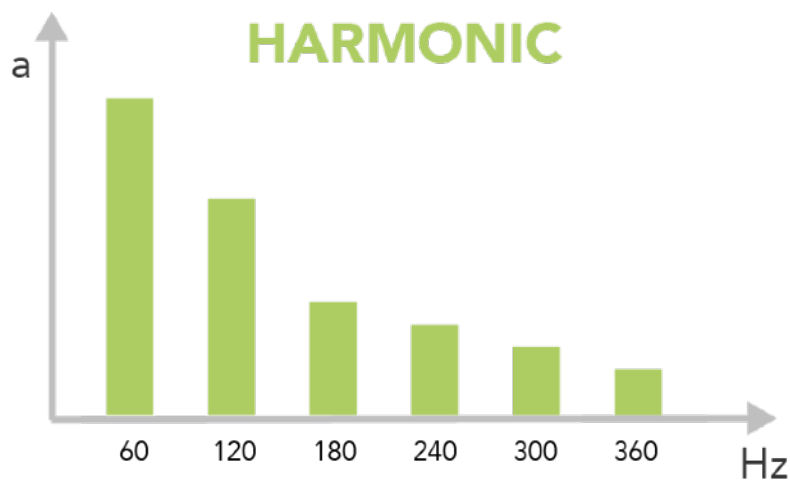
a trumpet note



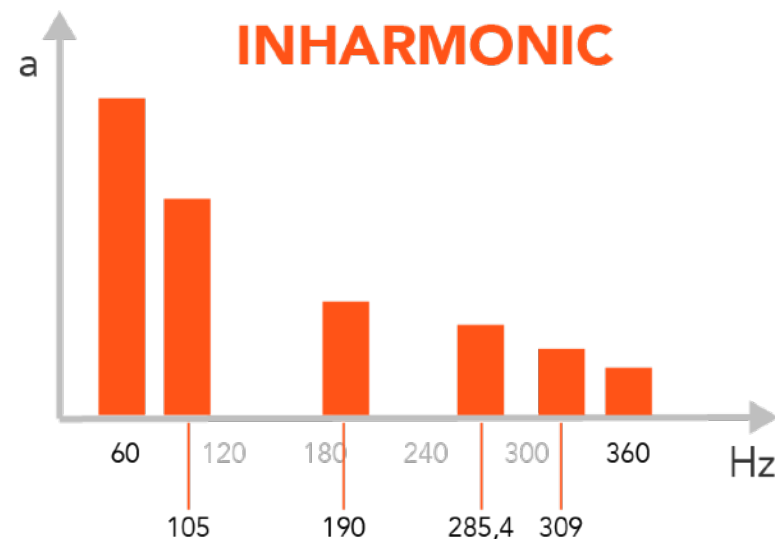
Sine waves in a timbre can be divided in two categories:

- The **Fundamental** (normally the lowest frequency sine wave with the largest amplitude)
- One or more **Overtones (partials)** to describe all sine waves above the fundamental

A spectrum can be:



when the overtones are integer multiples of the fundamental

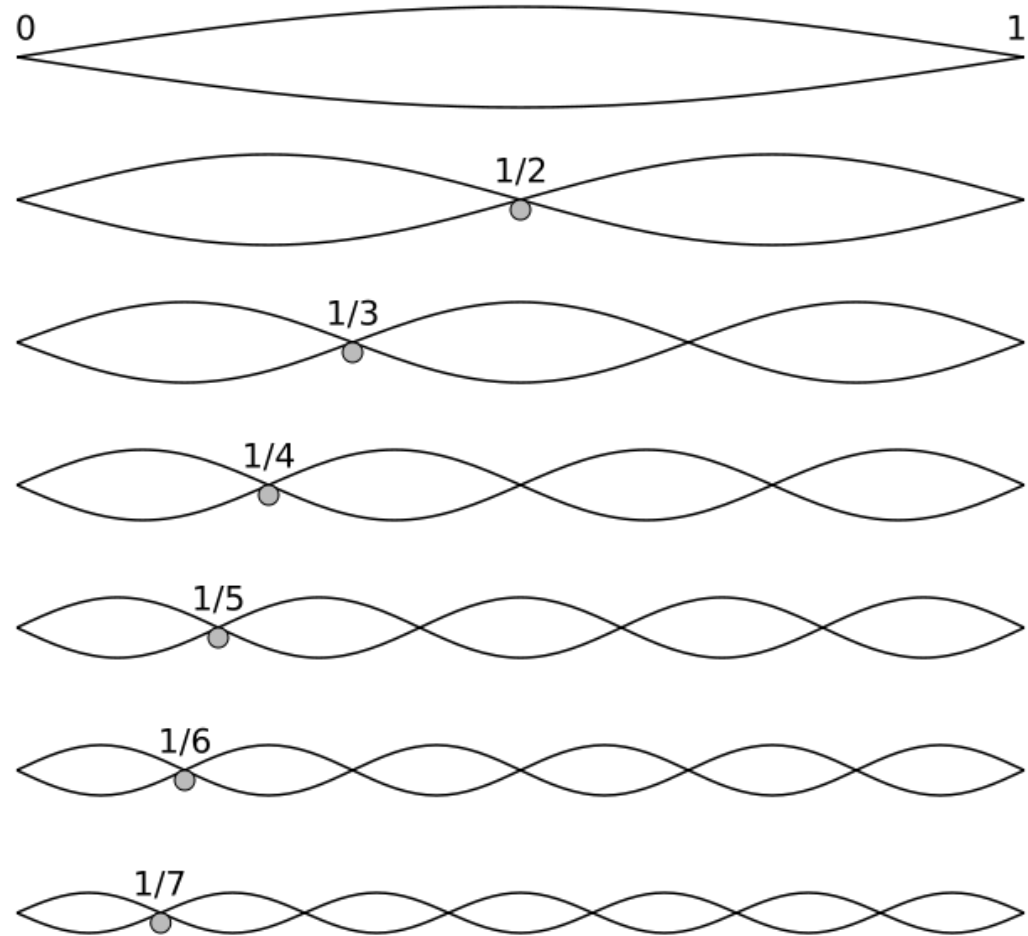


when the overtones are NOT integer multiples of the fundamental

# Harmonic overtones

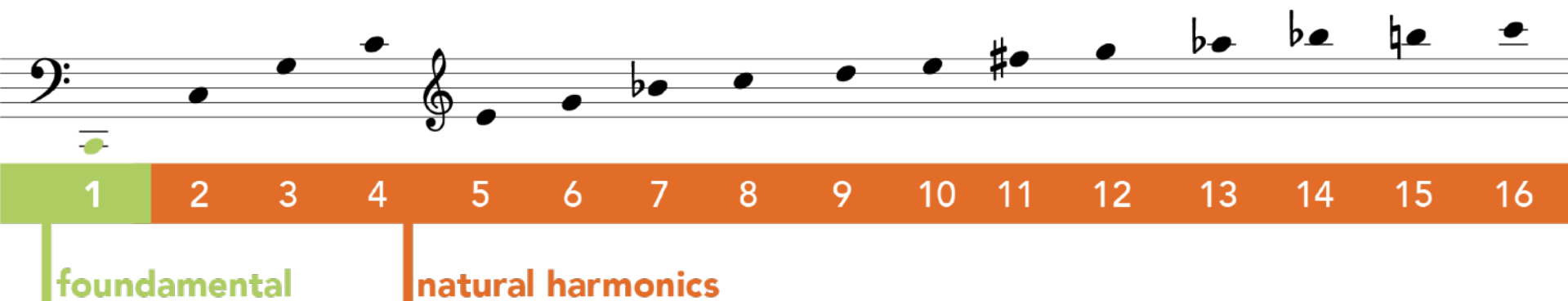
## Harmonic overtones

occurs when the overtones are integer multiples of the fundamental. In other words, the harmonics have frequencies that correspond to the fundamental frequency multiples by 1, 2, 3, 4, etc.



# Natural overtones

If we consider C as fundamental



Difference in hundredths of a semitone from the same note in the temperate scale



The series of notes obtained from the harmonics is the physical basis for **just intonation**.

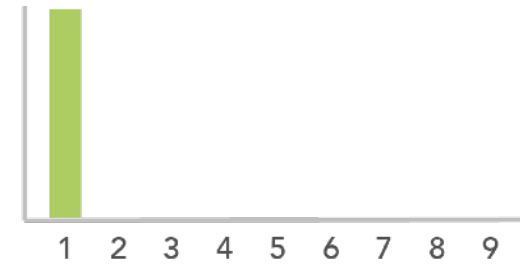
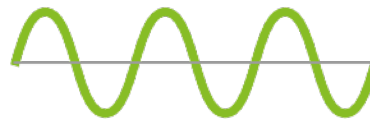
Contrarily, when we tune all semitones to be the same, we get a type of tuning called **Equal Temperament**.

I can calculate the frequency of any note  $x$  semitones away from a reference note or

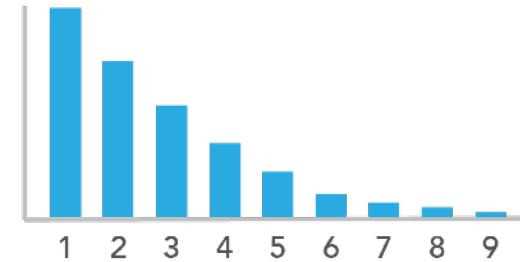
base frequency,  $f$ , using the following formula:  $f * r_{ET}^x$  where  $r_{ET} = \sqrt[12]{2}$

# Spectrum of "classic" waveforms

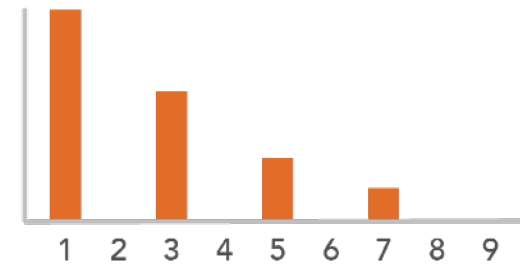
SINE



SAWTOOTH



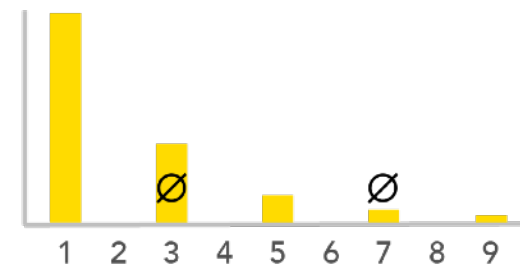
SQUARE



TRIANGULAR

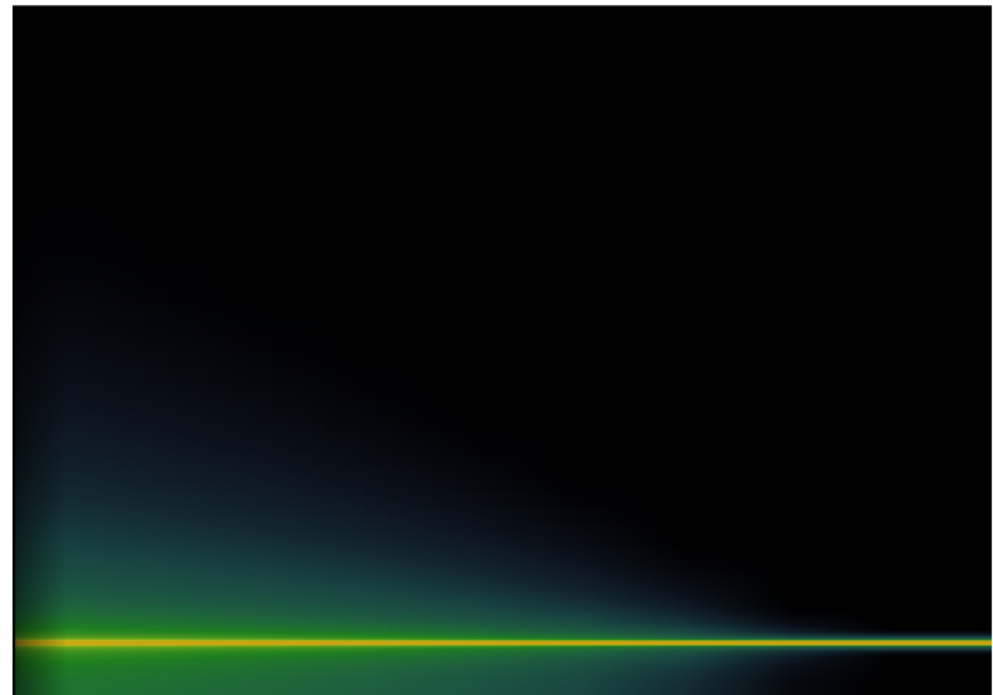
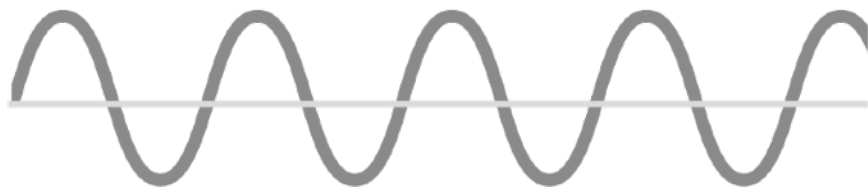
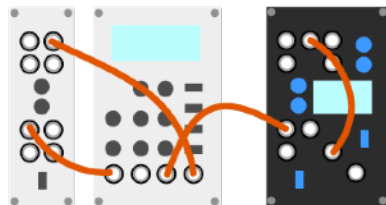


∅ = in antiphase



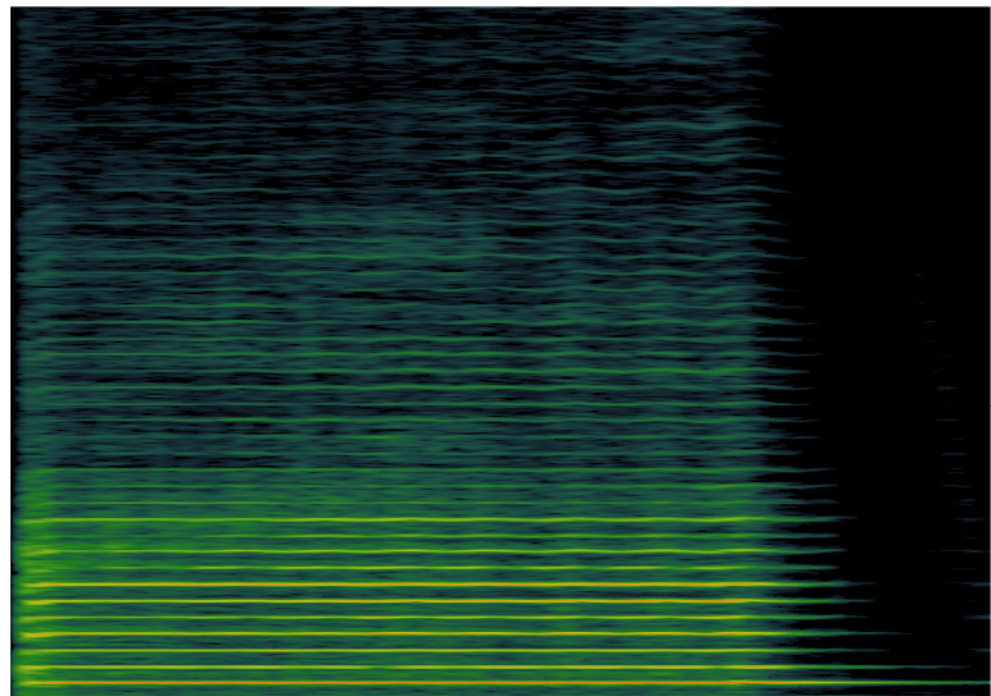
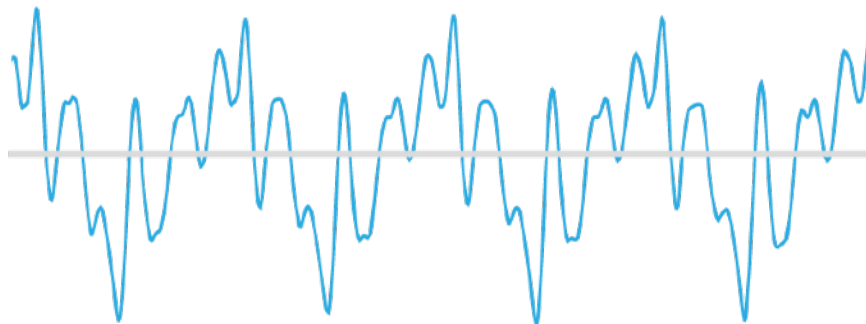
# Sine

## A4



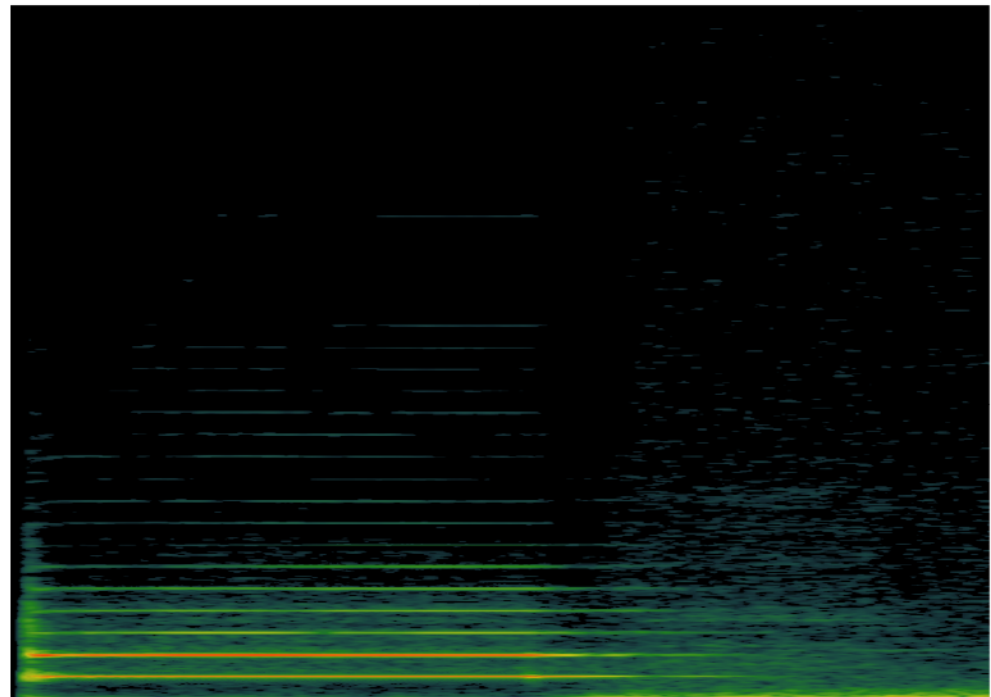
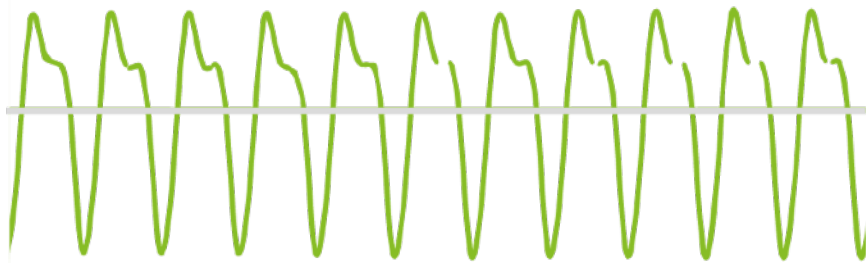
# Viola

C3

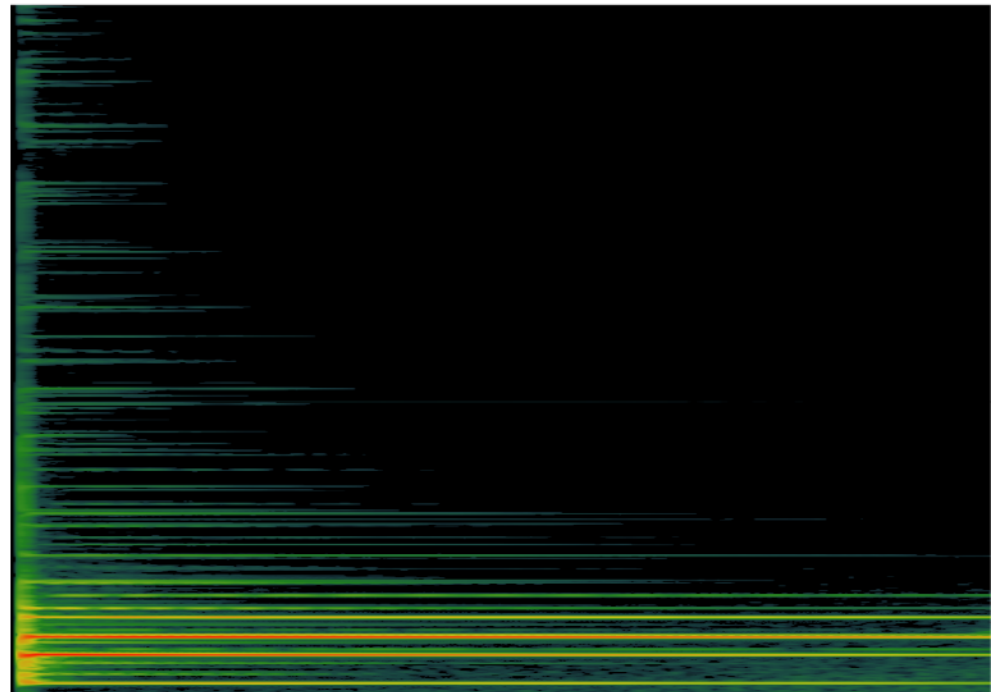
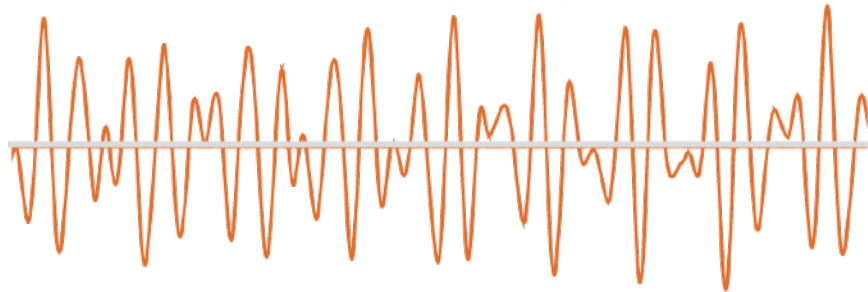


# French Horn

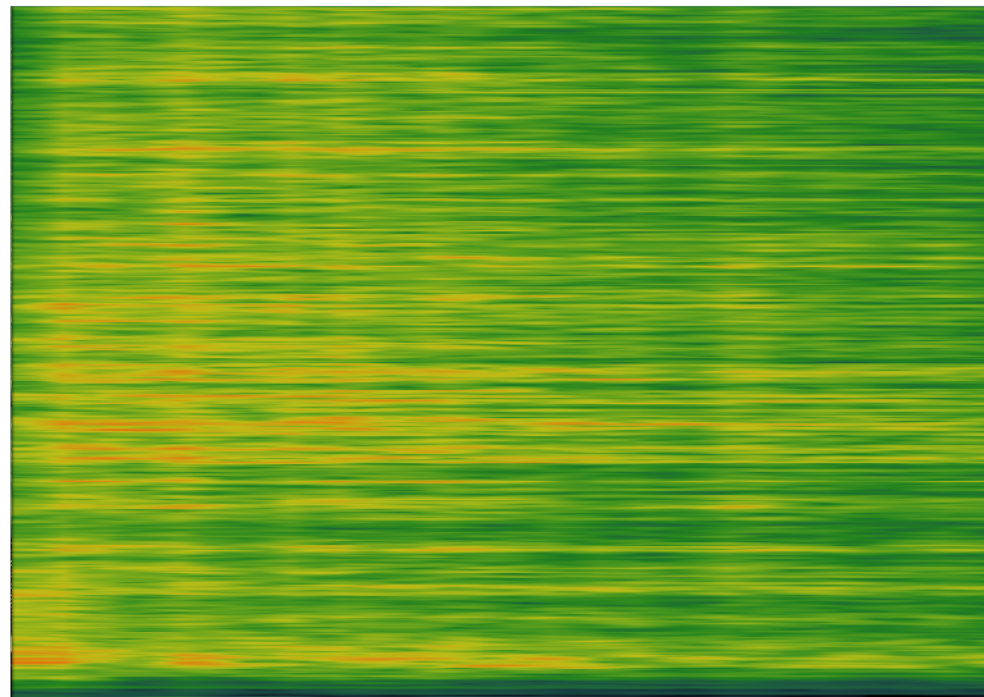
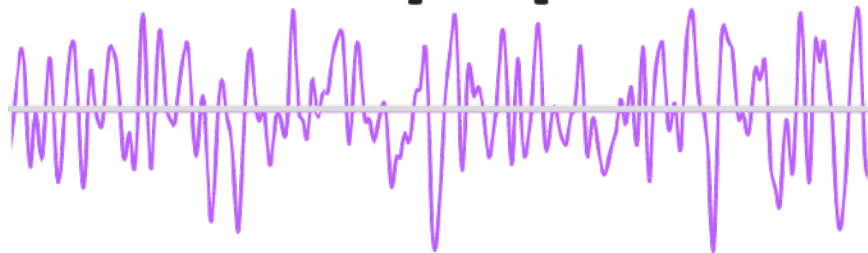
F3



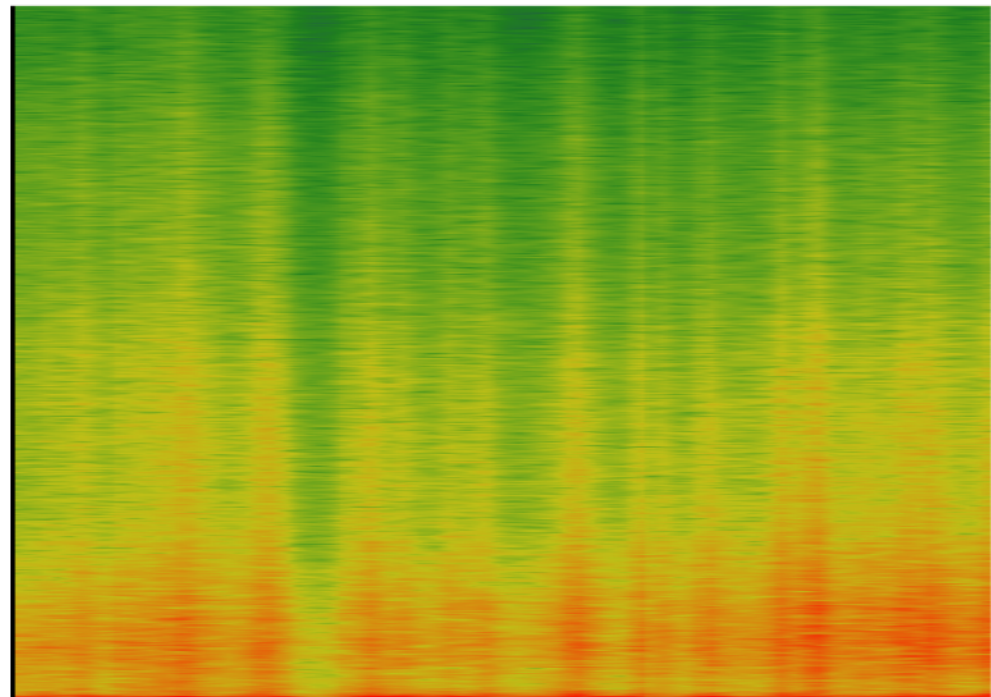
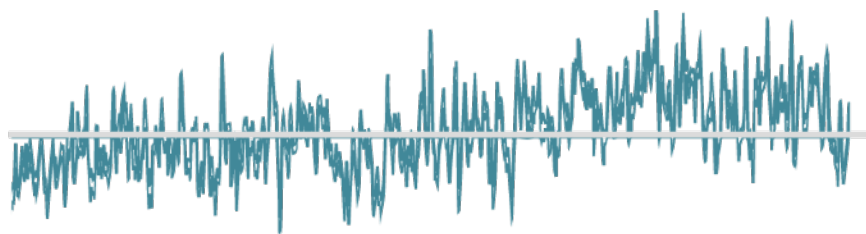
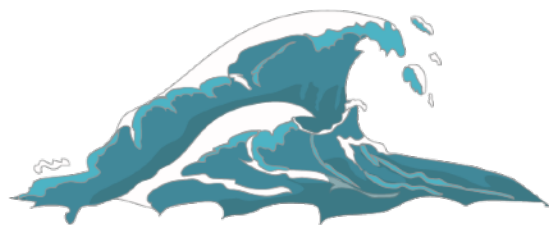
# Gong



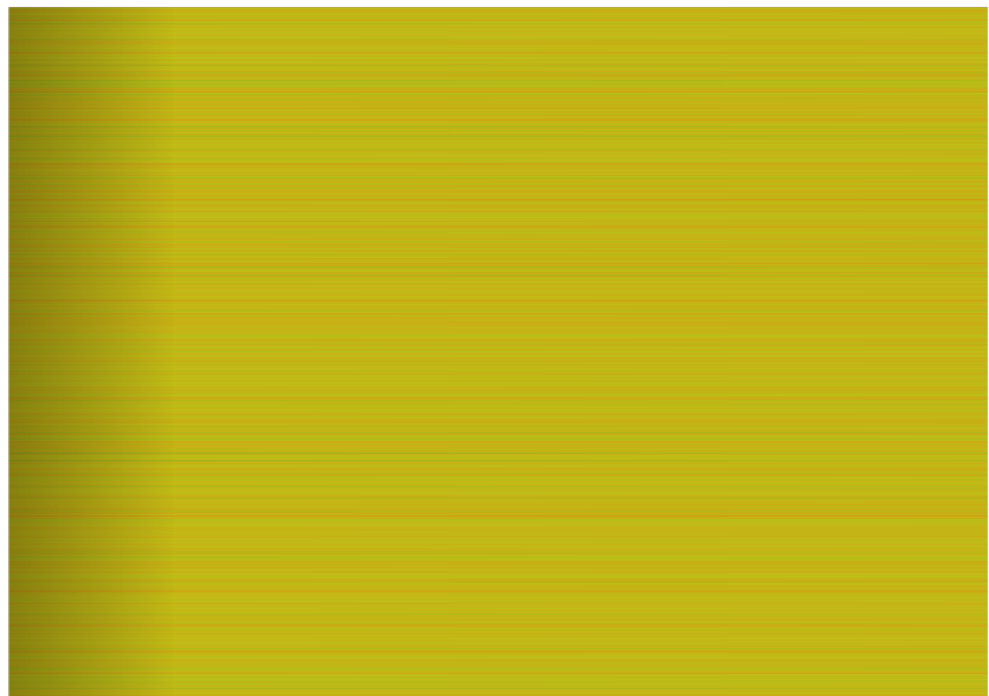
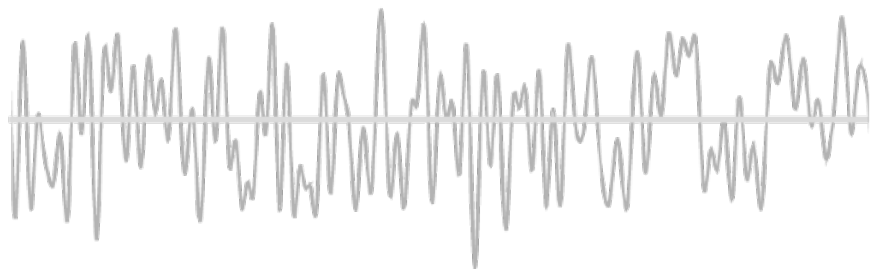
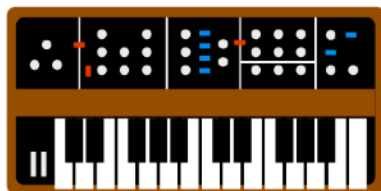
# Crash cymbal



# Sea wave



# White Noise



# PLAY WITH SOUND

MANUAL FOR ELECTRONIC  
MUSICIANS AND OTHER SOUND  
EXPLORERS



TOMMASO ROSATI  
TIMOTHY HSU

A Focal Press Book

ROUTLEDGE

T H E  
BOOK IS  
NOW  
AVAILABLE!