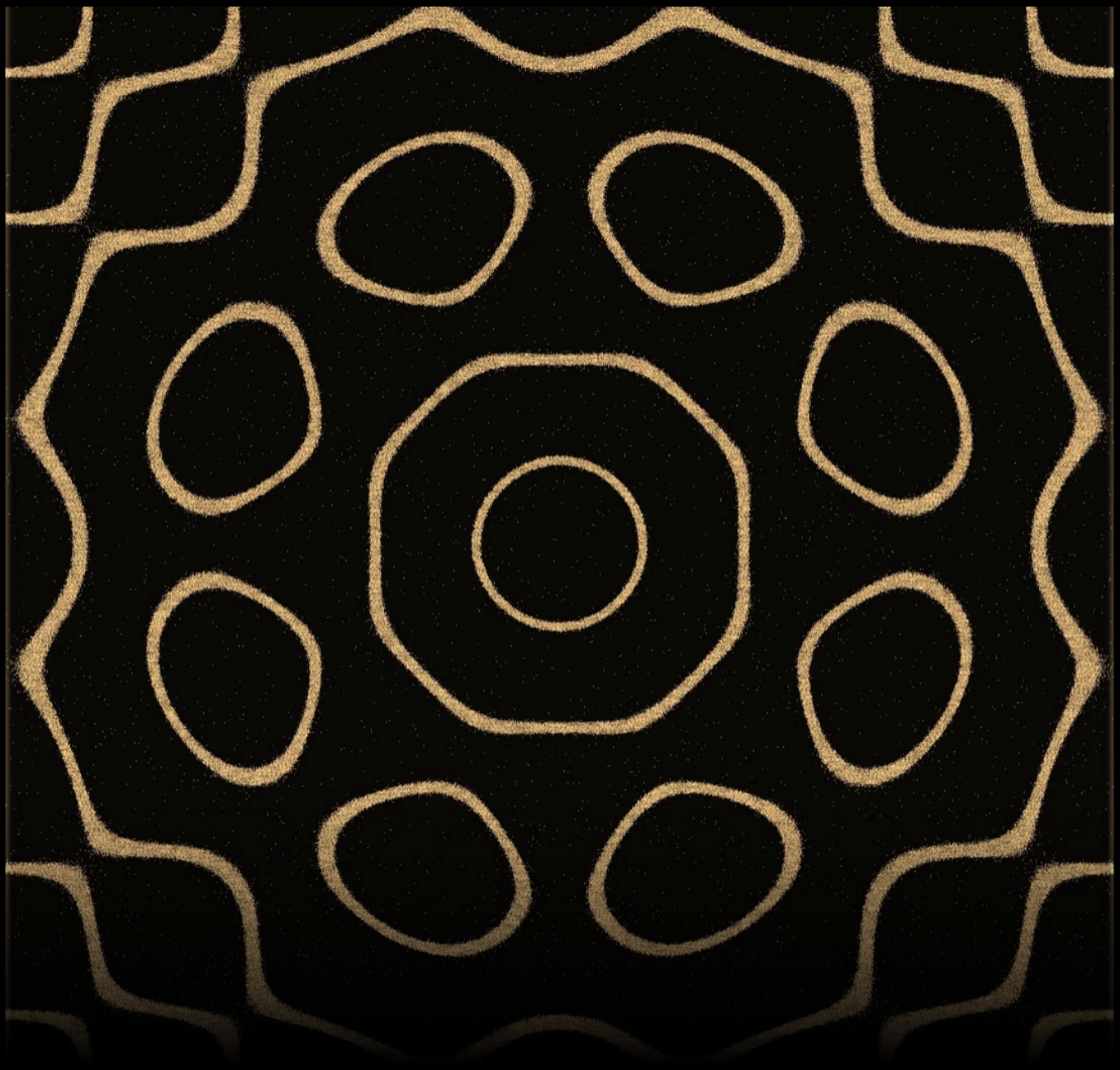
CYMATICA



HOW IT WORKS

The Chladni plate, calculated.

What Cymatica does with a sound, the physics behind each figure and why the result is precise.

cymatica.es

01 · THE EXPERIMENT

A plate, sand and a tone.

In 1787 Ernst Chladni ran a violin bow along the edge of a metal plate covered in sand. The sand jumped away from the areas that vibrated and settled on the lines that did not move. Each tone left a different figure.

Those still lines are called nodal lines. They are nobody's taste: they come from how a plate bends when it vibrates at a given frequency. That is why the same tone always gives the same figure, and why it can be calculated.

02 · WHAT CYMATICA DOES

Three steps, in real time.

1 · MEASURE

Reads the frequency

From the tone the app generates, an audio file or the microphone. It measures which frequencies are sounding and how strongly.

2 · CALCULATE

Solves the plate

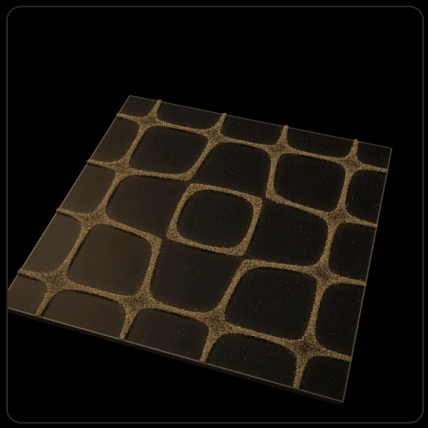
With that frequency it calculates how a square plate driven from its centre vibrates: which areas move and which stay still.

3 · SETTLE

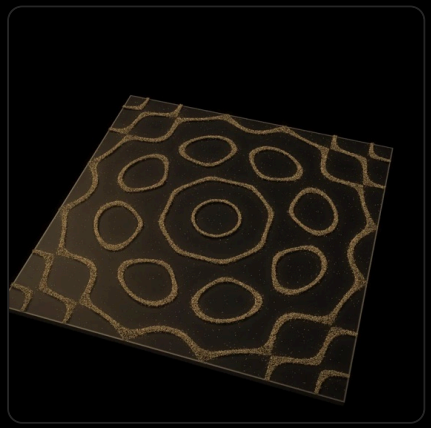
Releases the sand

Each grain is a particle. It jumps where the plate moves and stays where it does not. The figure appears by itself, as on a real plate.

None of this is stored images or hand-made animation. The figure you see is calculated in your browser, on the spot, from the sound that is playing. Change the frequency by one hertz and the calculation changes with it.



174 Hz · mode (4,4)



528 Hz · mode (8,6)



963 Hz · mode (12,6)

Every figure comes from a formula.

The shape

The plate is square, thin and free at its edges. Each possible way of vibrating has two whole numbers, n and m, which count how many times it bends in each direction. Its shape is:

$$\phi = \cos(n\pi x)\cdot\cos(m\pi y) + \cos(m\pi x)\cdot\cos(n\pi y)$$

The sand stays where ϕ is zero. This is Mary Waller's approximation for the free Kirchhoff plate, the classic description of Chladni figures.

The tone of each figure

$$f = C \cdot (n^2 + m^2), \text{ with } C = 5.5 \text{ Hz}$$

C stands for the size of the plate. With 5.5 Hz, each of the nine Solfeggio frequencies lands on a different figure. Two very close notes can share a figure, as on a real plate.

The setup: driven from the centre

As in real demonstrations, with a speaker underneath. From the centre, only figures with even n and m receive energy; the rest do not move there and do not appear. That is why the figures are symmetrical.

Between two figures

A tone almost never lands exactly on a figure. A real plate responds with several at once, and the closest one weighs most. Cymatica calculates that weight with the forced response of a damped oscillator:

$$w = |\phi(\text{centre})| \;/\; M \times \frac{1}{\sqrt{((f_k^2 - f^2)^2 + (\eta \cdot f_k \cdot f)^2)}}$$

With damping η = 0.01. The 2 to 4 heaviest figures are added together. So, as the frequency moves, one figure turns into the next without jumps.

FREQUENCY	MAIN FIGURE	ITS OWN TONE	OTHERS TAKING PART
174 Hz	(4,4)	176 Hz	(6,0) · (6,2) · (4,2), under 10 %
432 Hz	(8,4)	440 Hz	(8,2) 15 % · (6,6) 12 %
528 Hz	(8,6)	550 Hz	(10,0) 50 % · (10,2) 49 % · (8,4) 28 %
963 Hz	(12,6)	990 Hz	(10,8) 47 % · (12,4) 35 %

Values calculated by the app's core. The percentage is each figure's weight relative to the main one. On screen, the app always shows the mode (n,m) of the figure you are looking at.

04 · THE SAND

Grains that move, not an image.

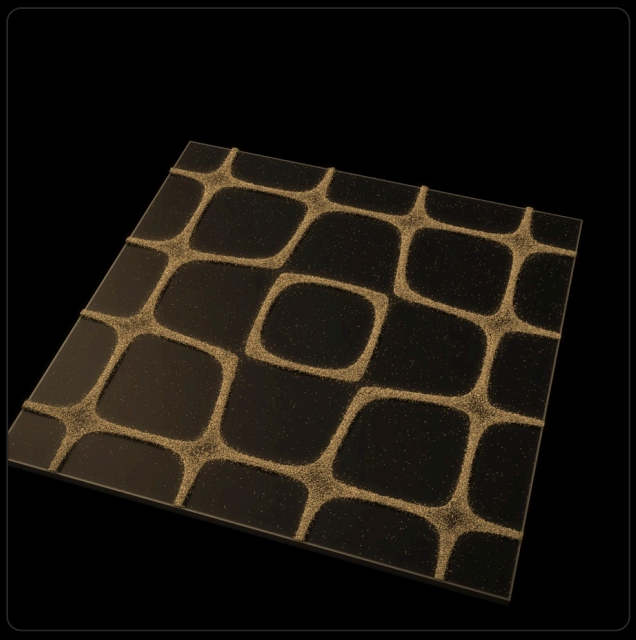
Cymatica's sand is a particle simulation. On a large screen that is around a hundred thousand grains, and the graphics card moves each one separately on every frame.

Each grain follows three rules, the same ones that explain the real plate:

- Where the plate moves, the grain jumps. The more it moves, the more it jumps.
- When it jumps, it tends to land where the plate moves less.
- Where the plate barely moves, the grain stays still.

The result is that the sand drifts to the nodal lines by itself and the figure appears little by little. When the tone changes, the previous figure comes apart and the new one forms, with no fades or cuts.

On a slower device the app lowers the number of grains by itself to stay smooth. The figure is the same.



Sand settled on the nodal lines of the plate.

05 · THE OTHER MODES

MODE	WHAT IT IS	WHAT IT CALCULATES
Chladni	Square plate driven from the centre.	Physical model
Mandala	A drum: a round membrane held at its edge. Its still lines are diameters and circles whose radii come from the zeros of the Bessel functions.	Exact nodal lines
XY	The Lissajous curve of the two channels, left against right.	The actual signal
Water	Waves on the surface of a liquid. The real wave at 528 Hz measures about 1.2 mm, so it is enlarged to be visible.	A model, not to scale. The app says so on screen

06 · WHY IT IS PRECISE

Four reasons you can check.

1 · It measures frequency in fine detail

It analyses the sound with two windows at once: a long one for low tones (16,384 samples) and a short one for high tones (4,096), and refines the result between points of the spectrum. In a test with computer-generated pure tones, the error was under 0.01 cents (a cent is one hundredth of a semitone).

2 · The figure is a formula, not an image

Nodal lines are calculated point by point with the equations on page 3. There are no textures or stored figures. The same frequency gives the same figure on any device, today and a year from now.

3 · It is checked against references

The model has automated tests that run on every change: the natural frequencies, the response weights, the figures of the nine Solfeggio tones. The drum's Bessel zeros are checked against the Abramowitz and Stegun tables.

4 · It separates what it calculates from what it does not

The physical figure is one thing. The geometry layers (Flower of Life, Metatron and the rest) are symbols from tradition and are labelled as such: they do not come from the sound. Whatever is an approximate model, like Water, says so on screen.

07 · WHAT IT IS NOT

The limits, stated plainly.

- **It is an ideal plate.** A real plate depends on its material, thickness, size and how it is held. Two different plates give different figures at the same frequency. Cymatica calculates one ideal square plate, always the same.
- **The size of the plate is a choice.** The constant C = 5.5 Hz was chosen so the app's frequencies give distinct figures. On another plate, 528 Hz would land on another figure.
- **The shape formula is an approximation.** Waller's describes the figures of a free plate well, but it is not the exact solution of the plate equation.
- **The names of the frequencies come from tradition.** That 528 Hz is linked to the solar plexus is not physics. The figure is.
- **It promises no effect on the body.** Cymatica shows what a sound looks like. What you feel while listening is yours.

Try it: cymatica.es/app