

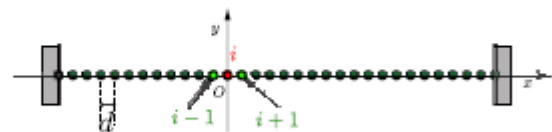
Chladniji vzorci

Valovni vozli na kvadratni opni



ANDREJ LIKAR

→ Na poti do velike fizikalne predavalnice so postavili začasno pregrado - med količka so napeli tanjšo verigo. Nisem si mogel kaj, da je pri hoji ne bi rahlo udaril ob količku in opazoval val, ki se je širil vzdolž verige, se na oddaljenemu koncu odbil in prihital nazaj. Valovanje je pač pojav, ki nas vedno znova prevzame. Ko pa se zavemo, da so svetloba, vseh vrst drugih elektromagnetnih valov, zvok v zraku in snoveh, seizmično gibanje zemeljske skorje, pojavi na vodni gladini in skrivnostno gibanje mikroskopskih delcev snovi tudi valovanja, se zavemo, da valovanje ni le zanimivo, je v jedru fizike. Pa se poigrajmo z valovanjem na nizu in v mrežo medsebojno povezanih kroglic. Poskusi s praviimi kroglicami bi bili prezahtevni, zato bomo v igro pritegnili računalnik.

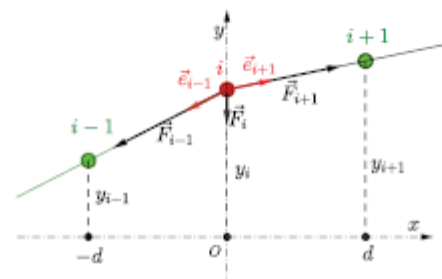


SLIKA 1.

Niz elastično spetih kroglic med nepremičnima stenama.

Enako velike kroglice v mislih povežemo v niz z elastično vrvico. Razdalja d med sosednjima krogli-

da se po svoje gibljejo. Kako se bodo kroglice v nizu odzvale na to motnjo?



SLIKA 2.

K izpeljavi zakona gibanja kroglic v nizu.

Če želimo ponazoriti gibanje kroglic v nizu z računalnikom, moramo poznati enačbo njihovega gibanja. Ta bo seveda sledila iz Newtonovega zakona, ki pravi, da je pospešek izbrane kroglice sorazmeren vsoti vseh sil, ki nanjo delujejo. Na Sliko 2 je prikazana izbrana, denimo i -ta kroglica, ter njeni sosedi z oznakama $i-1$ in $i+1$. Edino ti dve sosedi preko elastične vrvice delujeta na izbrano kroglico i . Vsote njunih sil s slike ni težko določiti. Enotska vektorja (vektorja brez enote in dolžino 1, nakazujeta le smer) od kroglice i proti sosedama sta:

$$\vec{e}_{i-1} = \frac{1}{\sqrt{d^2 + (y_{i-1} - y_i)^2}} (-d, y_{i-1} - y_i)^T,$$

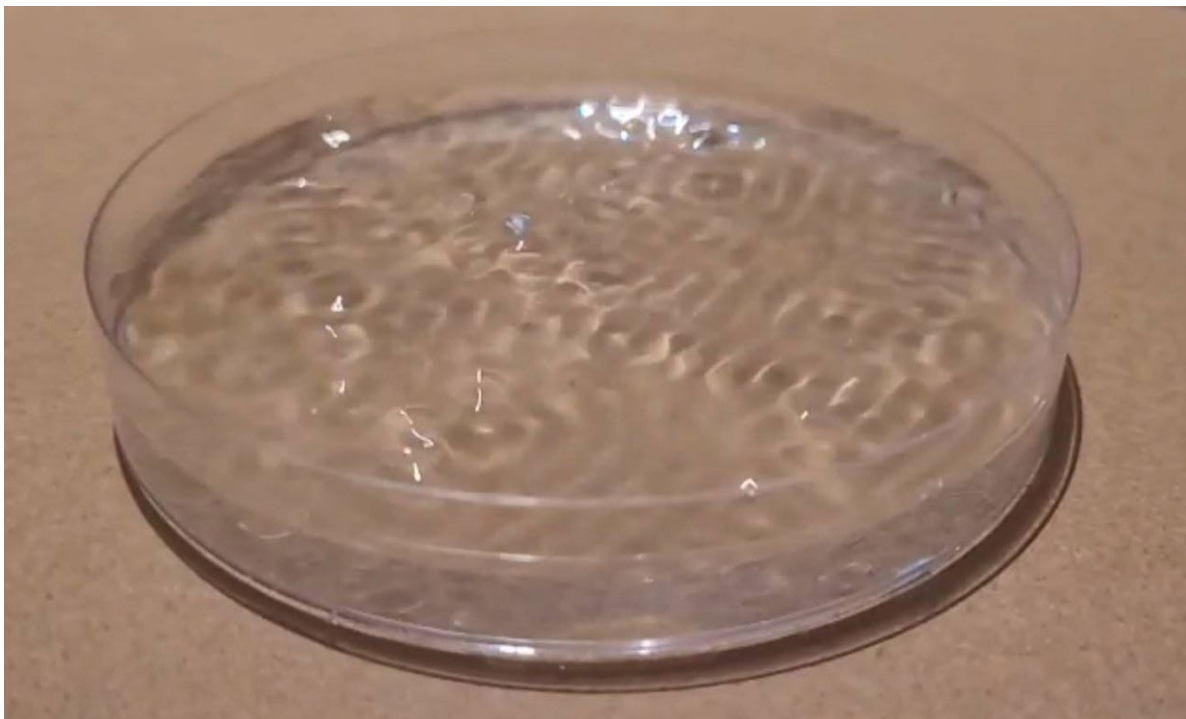
vsakdan



vsakdan - kaj opazite?



Faradayevi valovi



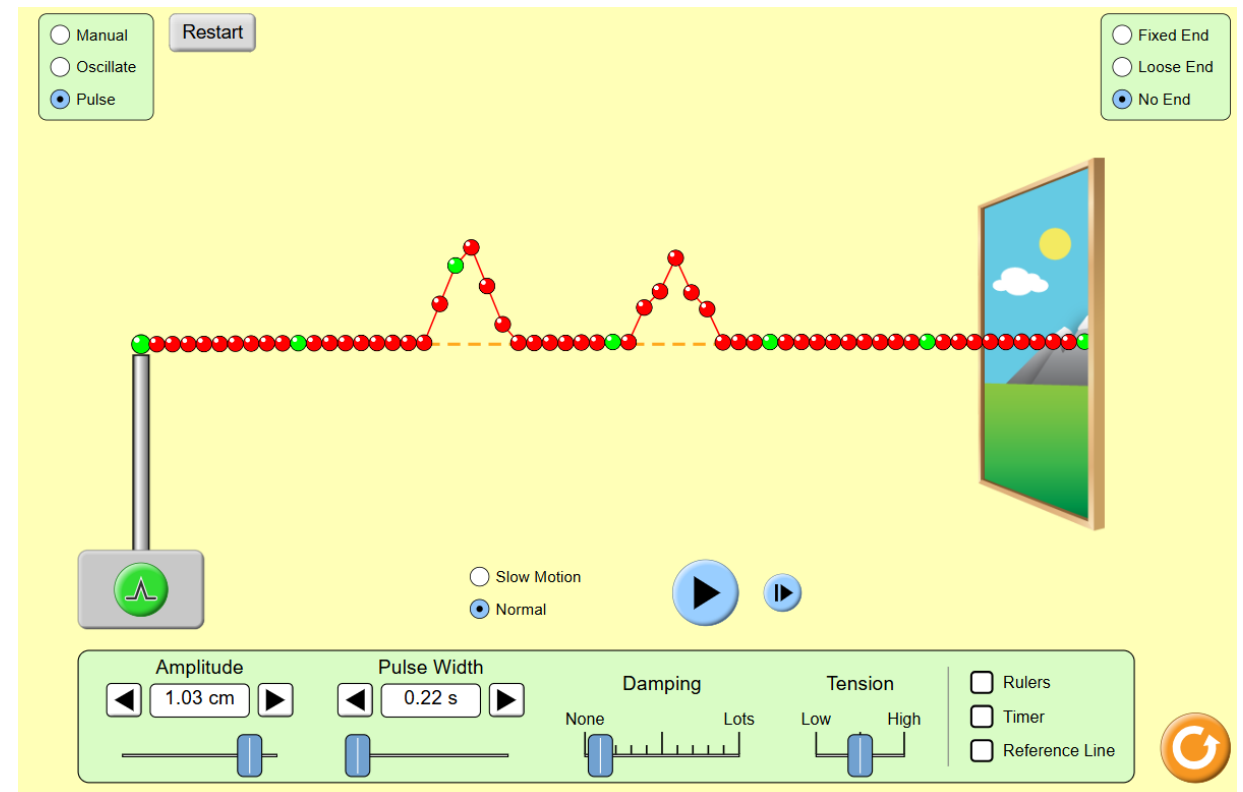
Bremps, CC BY-SA 4.0



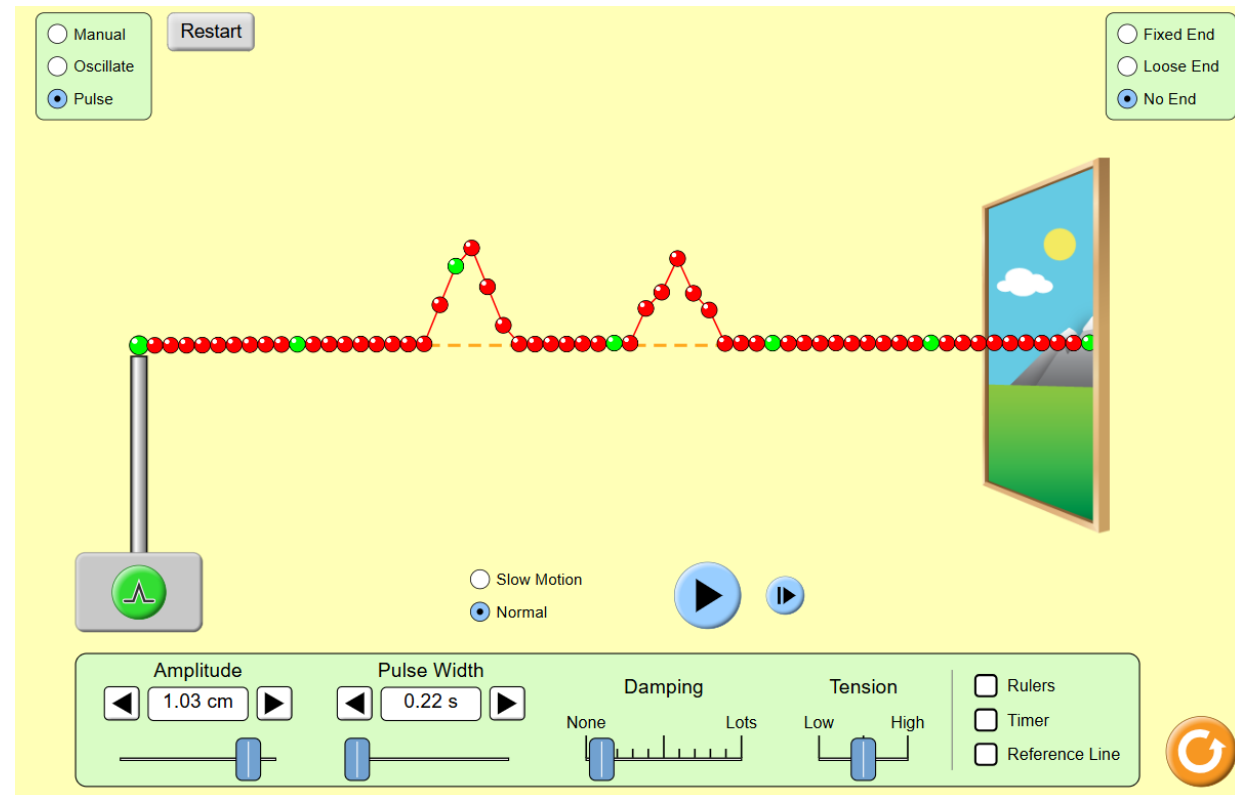
Institute of Physics, CC BY 3.0

opazujmo

- https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_all.html



- valovanje
- vzbujanje
- motnja
- hitrost



opazujmo

The image shows a digital simulation of a wave on a string. The wave is represented by a series of red spheres connected by a red line, oscillating vertically around a horizontal dashed orange line. The wave starts at a green sphere on the left, which is attached to a grey circular oscillator. The wave ends at a green sphere on the right, which is attached to a rectangular frame containing a landscape image of a sun, clouds, and mountains. The simulation is set to 'Oscillate' mode, as indicated by the selected radio button in the top-left control panel. The bottom control panel includes sliders for Amplitude (1.03 cm), Frequency (1.50 Hz), Damping (set to 'None'), and Tension (set to 'Low'). There are also checkboxes for 'Rulers', 'Timer', and 'Reference Line'. A 'Restart' button is located at the top center, and a 'Slow Motion' toggle is at the bottom center. A play button and a pause button are also present. A circular refresh icon is in the bottom right corner.

Manual
 Oscillate
 Pulse

Restart

Fixed End
 Loose End
 No End

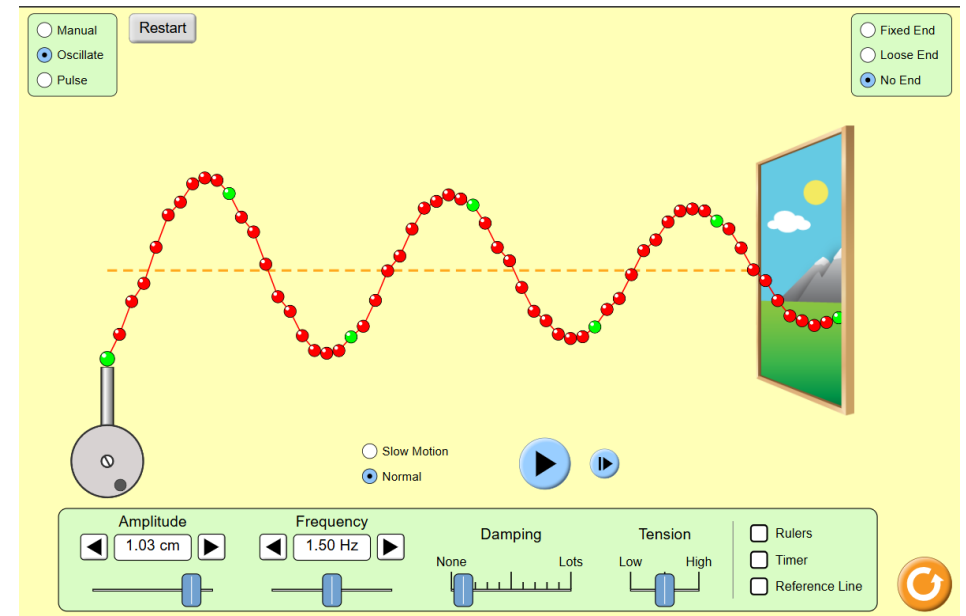
Slow Motion
 Normal

Amplitude: 1.03 cm
Frequency: 1.50 Hz
Damping: None to Lots
Tension: Low to High

Rulers
 Timer
 Reference Line

opazujmo

- periodično vzbujanje
- frekvenca
- valovna dolžina



opazujmo

The image shows a physics simulation interface for a wave pulse on a string. The main area displays a string fixed at both ends, with a pulse traveling from left to right. The pulse is represented by a series of red dots connected by a red line, forming a triangular shape. A green dot is at the leading edge of the pulse. A dashed orange line indicates the pulse's width. The string is supported by two vertical grey poles. The background is light yellow.

Control Panel (Top Left):

- Manual
- Oscillate
- Pulse
- Restart

End Conditions (Top Right):

- Fixed End
- Loose End
- No End

Speed Control (Bottom Center):

- Slow Motion
- Normal

Amplitude Control (Bottom Left):

Amplitude: 1.03 cm

Pulse Width Control (Bottom Center-Left):

Pulse Width: 0.22 s

Damping Control (Bottom Center-Right):

Damping: None to Lots (slider)

Tension Control (Bottom Right):

Tension: Low to High (slider)

Options (Bottom Right):

- Rulers
- Timer
- Reference Line

Navigation (Bottom Center):

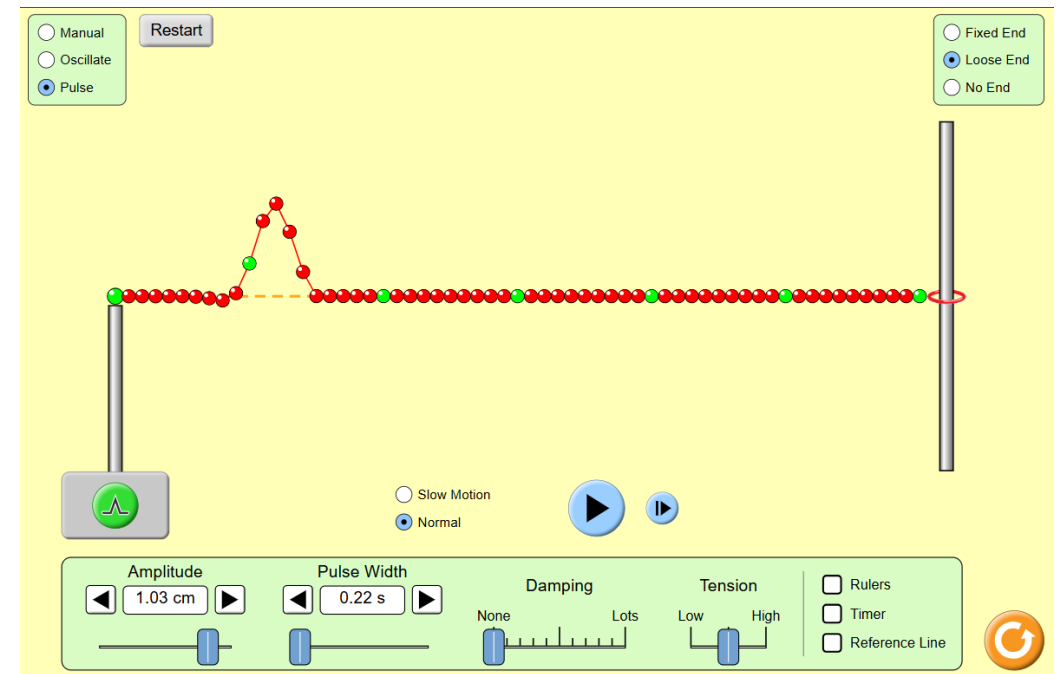
- Play button
- Pause button

Refresh (Bottom Right):

- Refresh button

opazujmo

- odboj
- faza odbitega valovanja



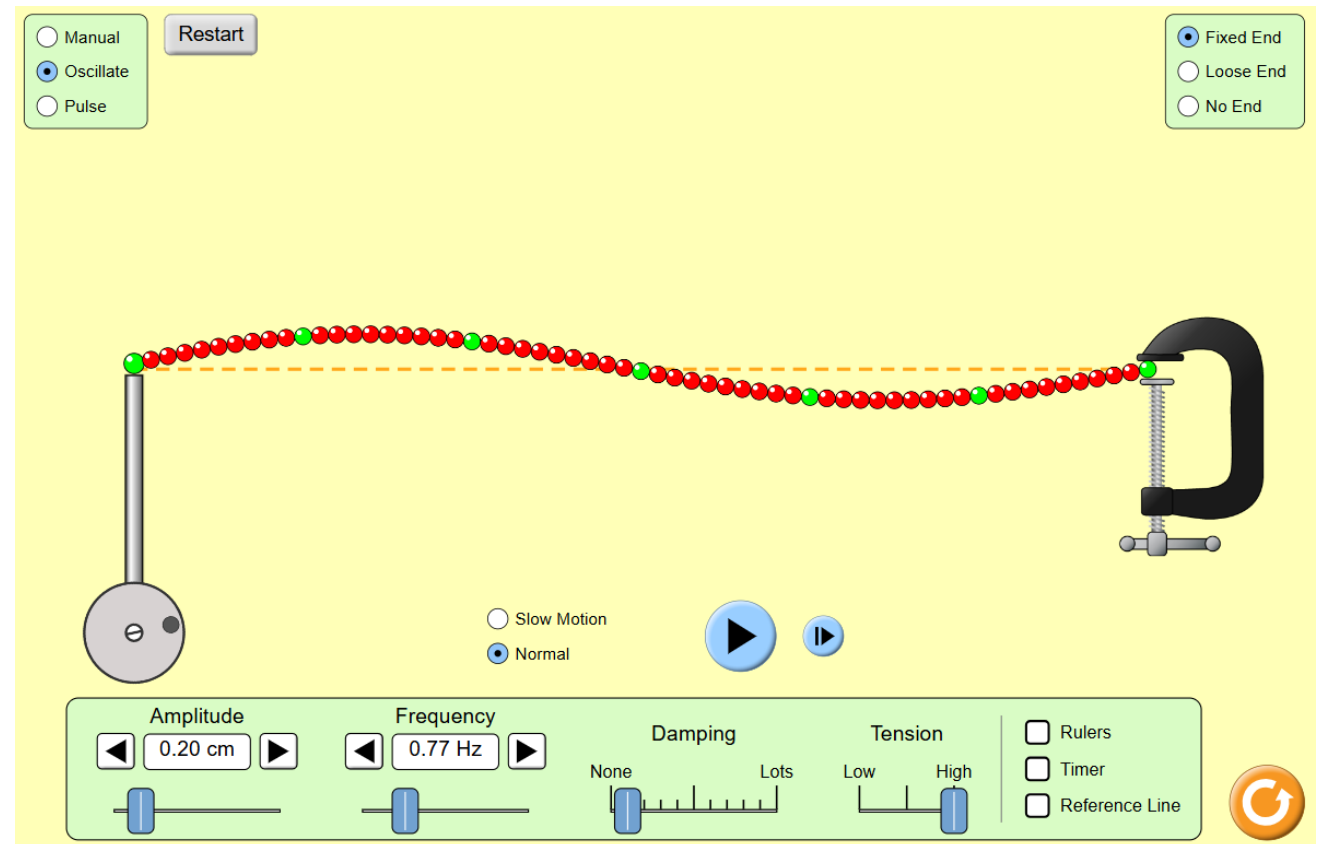
opazujmo

The image shows a physics simulation interface for a string wave experiment. The main area displays a string of red beads forming a wave pulse, with a dashed orange line indicating the equilibrium position. The string is attached to a vertical rod on the left and a C-clamp on the right. The interface includes several control panels:

- Mode Selection:** Radio buttons for Manual, Oscillate (selected), and Pulse.
- Restart:** A button to reset the simulation.
- End Condition Selection:** Radio buttons for Fixed End (selected), Loose End, and No End.
- Speed Control:** Radio buttons for Slow Motion and Normal (selected).
- Amplitude:** A slider and a text box showing 0.20 cm.
- Frequency:** A slider and a text box showing 0.77 Hz.
- Damping:** A slider ranging from None to Lots.
- Tension:** A slider ranging from Low to High.
- Options:** Checkboxes for Rulers, Timer, and Reference Line.
- Play Buttons:** A large blue play button and a smaller blue play button.
- Refresh:** An orange circular refresh button in the bottom right corner.

opazujmo

- stoječe valovanje
- hrbet
- vozlel



valovna enačba

- $\frac{\partial^2 u}{\partial t^2} = c^2 \nabla^2 u$
- robni in
- začetni pogoji

Chladnijevi vzorci



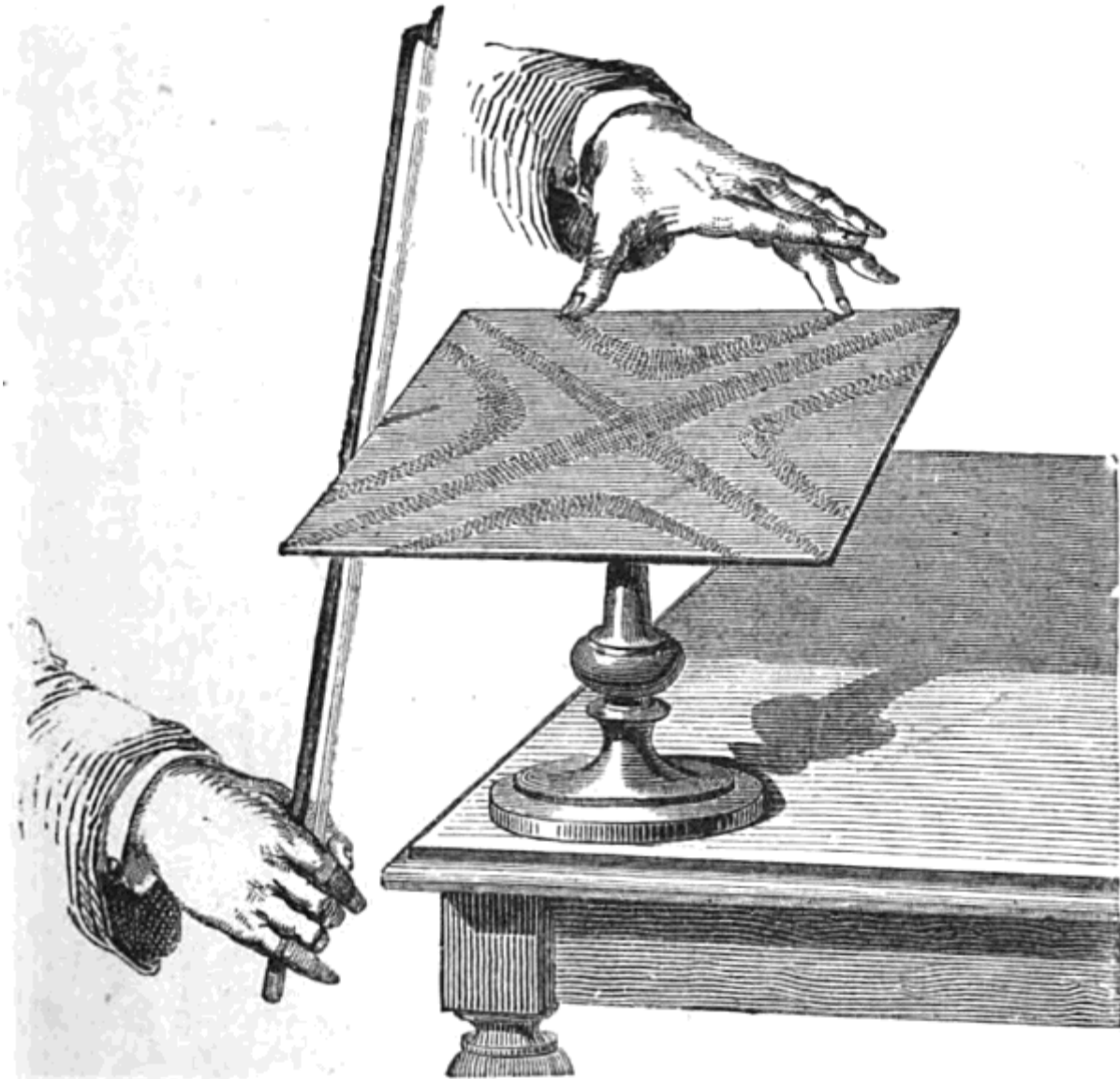
Ernst Chladni

nemški fizik, astronom in glasbenik, 1756 - 1827, Wittenberg, Nemčija, Breslau (sedaj Wrocław, Poljska).

Chladni je raziskoval nihajoče plošče in računal hitrost zvoka za različne pline. Zaradi tega ga imajo včasih za »očeta akustike«. Opravil je tudi pionirsko delo pri raziskovanju meteoritov. Leta 1794 je pokazal, da so nezemeljskega izvora.

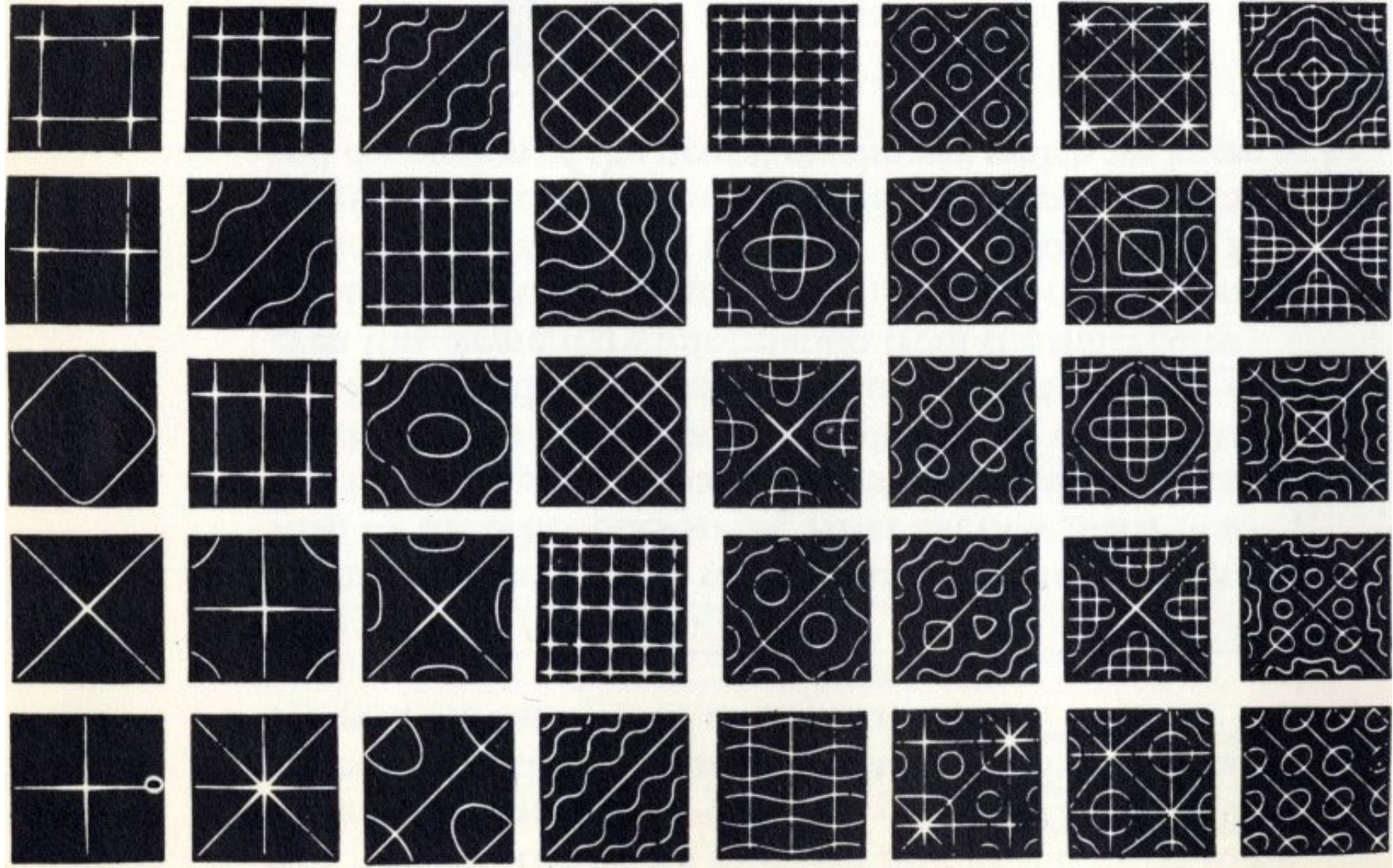
Po njem se imenuje krater Chladni na Luni in asteroid 5053 Chladni





- Pariška akademija 1808
- Napoleon ponudi nagrado za najboljšo matematično razlago
- Sophie Germain





John Tyndall, 1869

matematicni opis

[chladni.nb](#)

```
Manipulate[ContourPlot[Cos[kxx Pi/2]Cos[kyy Pi/2]  
+ Cos[kyx Pi/2]  
× Cos[kxy Pi/2], {x, -1,1}, {y, -1,1}, PlotRange -  
> {-0.1,0.1}], {kx, 1,8,1}, {ky, 1,8,1}]
```

