Explaining the **Audio Visualizer** functionality

A short introduction to the sound spectrum

- The **Sound spectrum** = oscillations with audible frequencies: 20→20.000 Hz
- The **sinus** = most simple tone
- Try the **audio tone generator app** to generate sine waves

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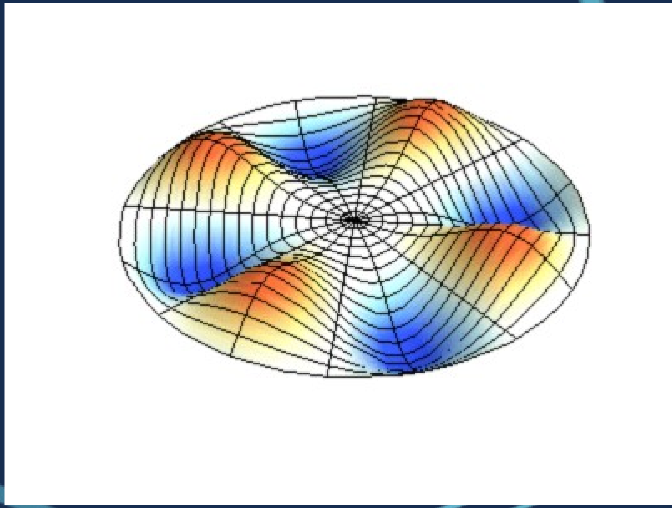
Vibrating objects

- Acoustic properties of a vibrating object
  - ➔What material?
  - ➔Shape?
  - ➔Surrounding materials?

- Membrane / thin plate
  - Tense, flat and thin properties
    - ➔Good sound propagation



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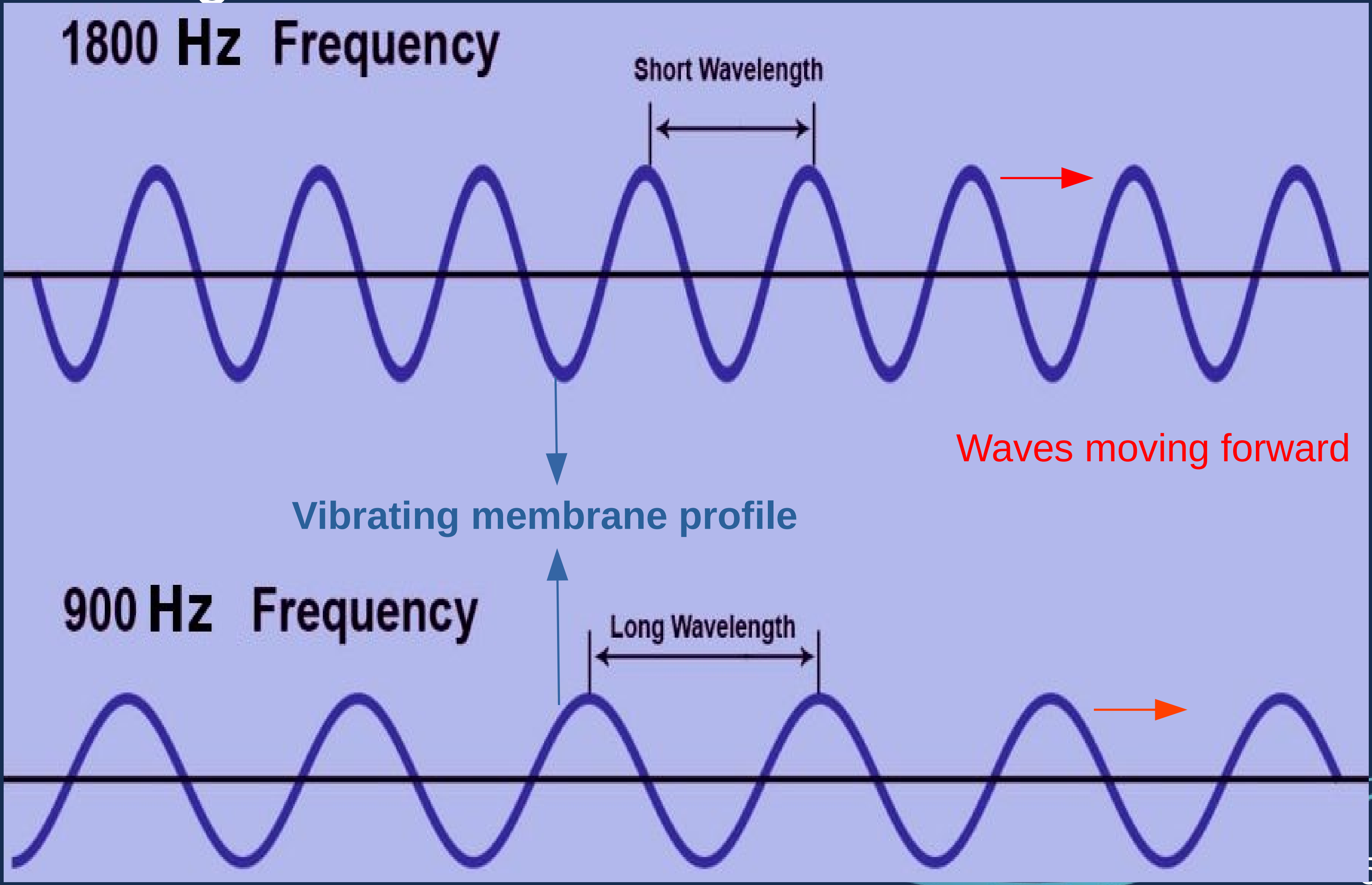
Forced vibrations and resonance

- Object + acoustic signal ➞ object vibrates along
  - ➔same sinuses
  - ➔but timing & amplitude can change
- Membrane / plate have much **air contact**
  - ➔**Responsive** to acoustical impacts

Traveling waves

- Membrane / plate: **same speed** for all vibrations
- Wavelength:



Reflecting waves

- **At the ends** of the membrane
  - Incoming traveling waves are **bounced back**
  - ➔ Making **a new traveling wave** running in the **opposite direction**

Standing waves

- There can be several traveling waves at once in the membrane
- But the membrane can only be in one place!
  - ➔ The shape = sum of all traveling waves

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➔ What happens with **2 identical waves** going in **opposite direction**?

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Standing waves

·So, the sum of a traveling wave with its reflection becomes...

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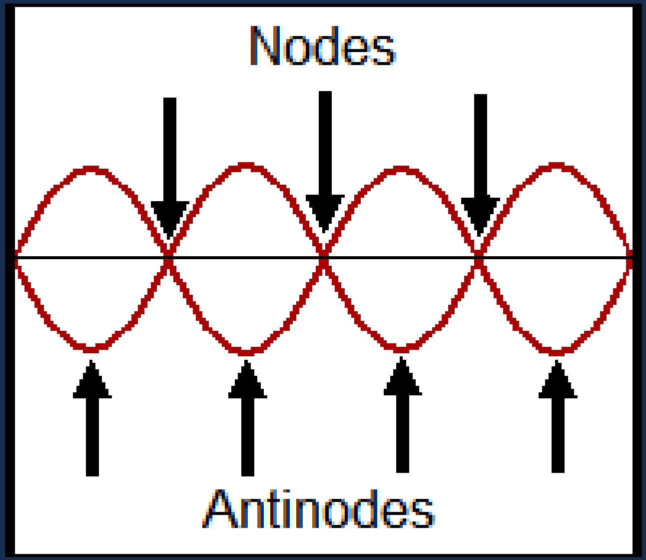
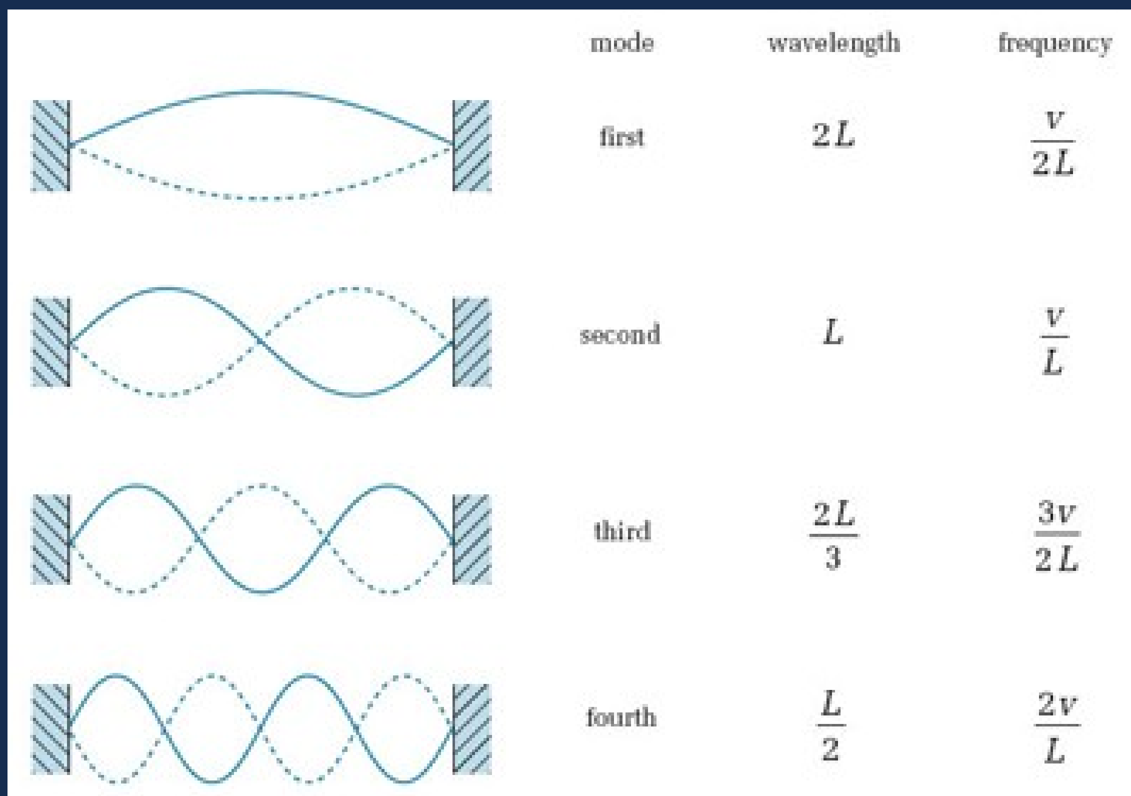
·Vibration **nodes** and **antinodes**:



·On a membrane: similar, but in 2D → patterns

Vibration modes

- Reflections all over the place … many waves!
- Some wavelengths match well with the membrane dimensions:



vibration modes occurring at **resonance frequencies**

- At other frequencies: less responsive

Vibration modes

- Similarly in a membrane ...

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- In reality: sound vibrations are much faster
  - ➔ They become invisibly small :-/

Visualizations: 'Chladni patterns'

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- Visualizing the vibration modes
- Use tone generator app to experiment

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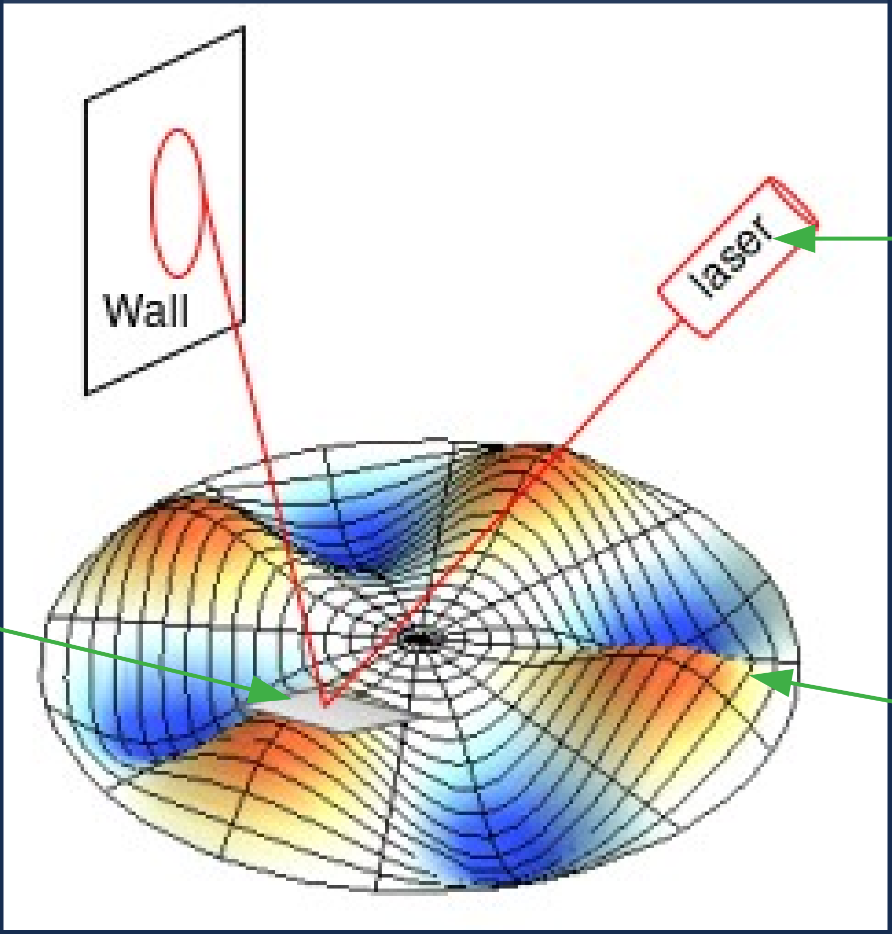
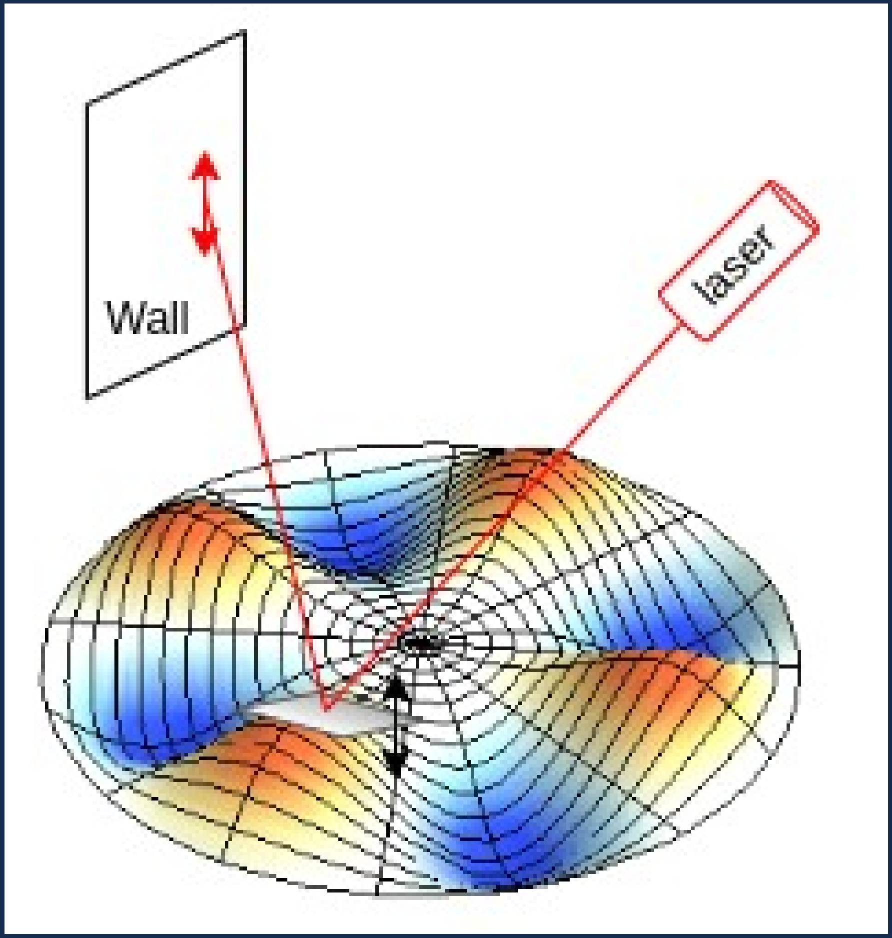
Visualizations
vibration-reflected laser



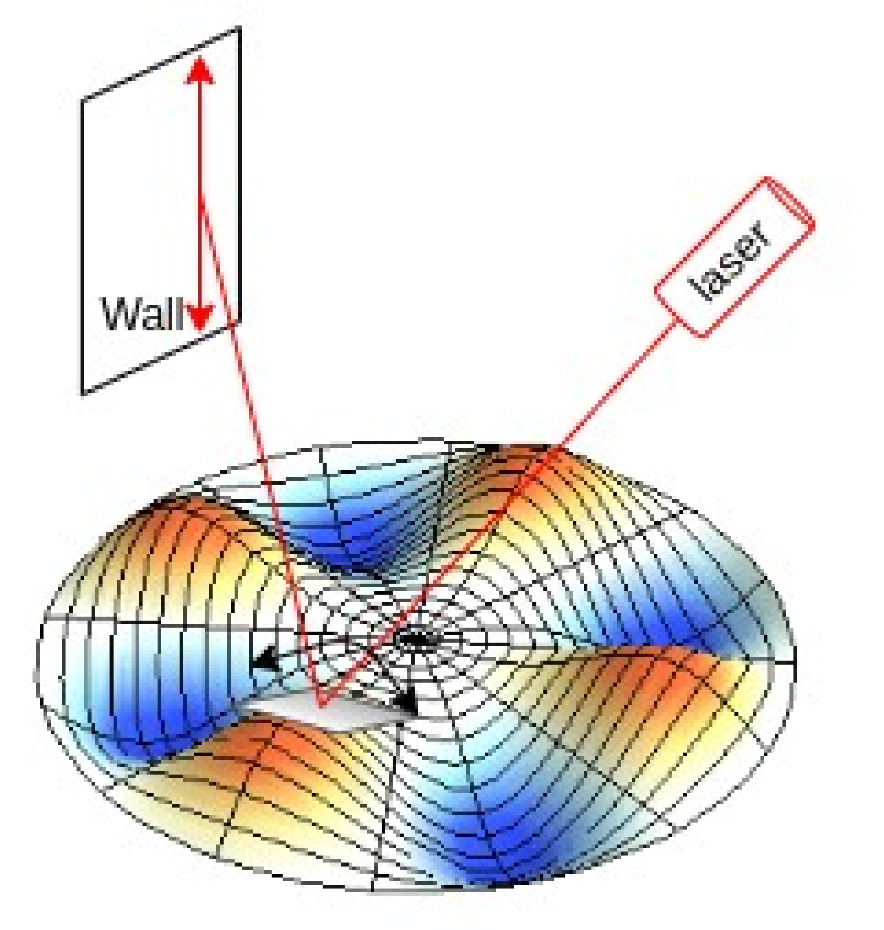
- Visualizing a single point on the membrane.
- But: in detail

Visualizations
vibration-reflected laser



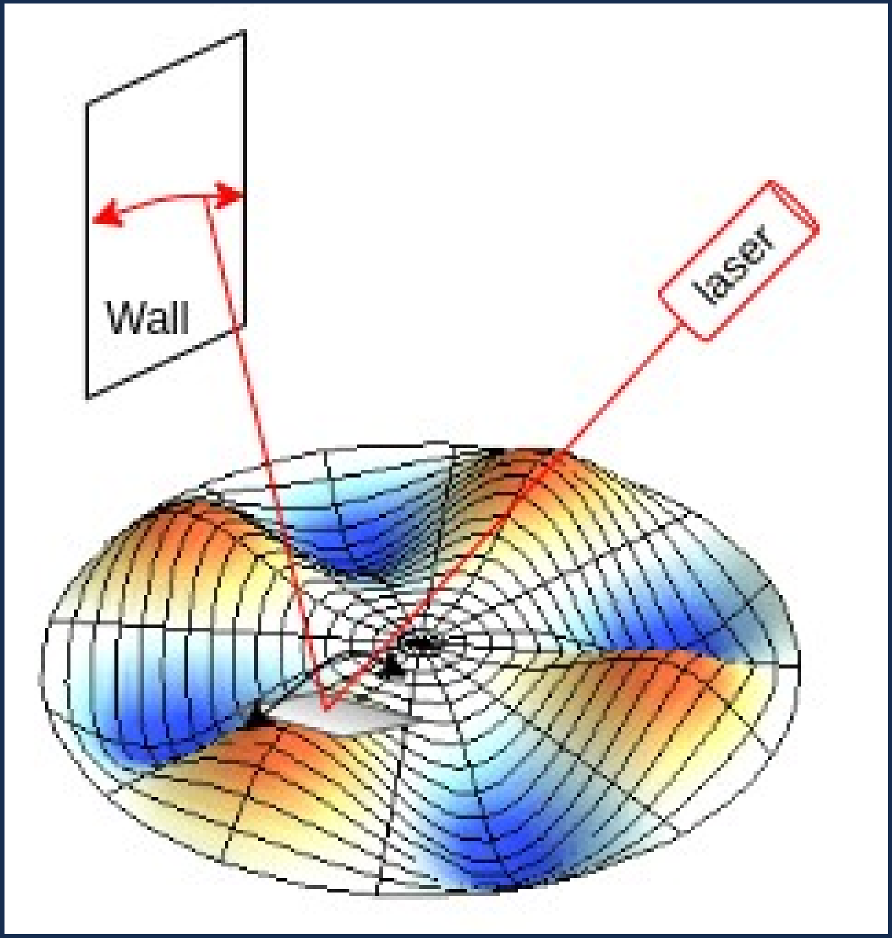
Membrane up-down: very small in reality

Visualizations
vibration-reflected laser



Membrane twist 1: amplified with distance to wall!
→vertical line

Visualizations
vibration-reflected laser



Membrane twist 2: amplified…
➔horizontal line

Visualizations
vibration-reflected laser

Recalling the vibration modes ...

·The **strongest twist motion** happens

- At the resonance frequencies
- Mirror on vibration node (→ here: twist 1 > 2)

Lissajous patterns

- Complex sound = complicated: many vibration modes together
- Sinus = easy
  - Only most nearby vibration mode is excited
  - Mirror twists 1 & 2
    - same frequency
    - amplitude and phase mostly different
    - → We see a range of **oval shapes**
- In practice, non-oval shapes due to:
  - Wall at an angle
  - laser on edge of mirror
  - Too strong vibrations: saturation

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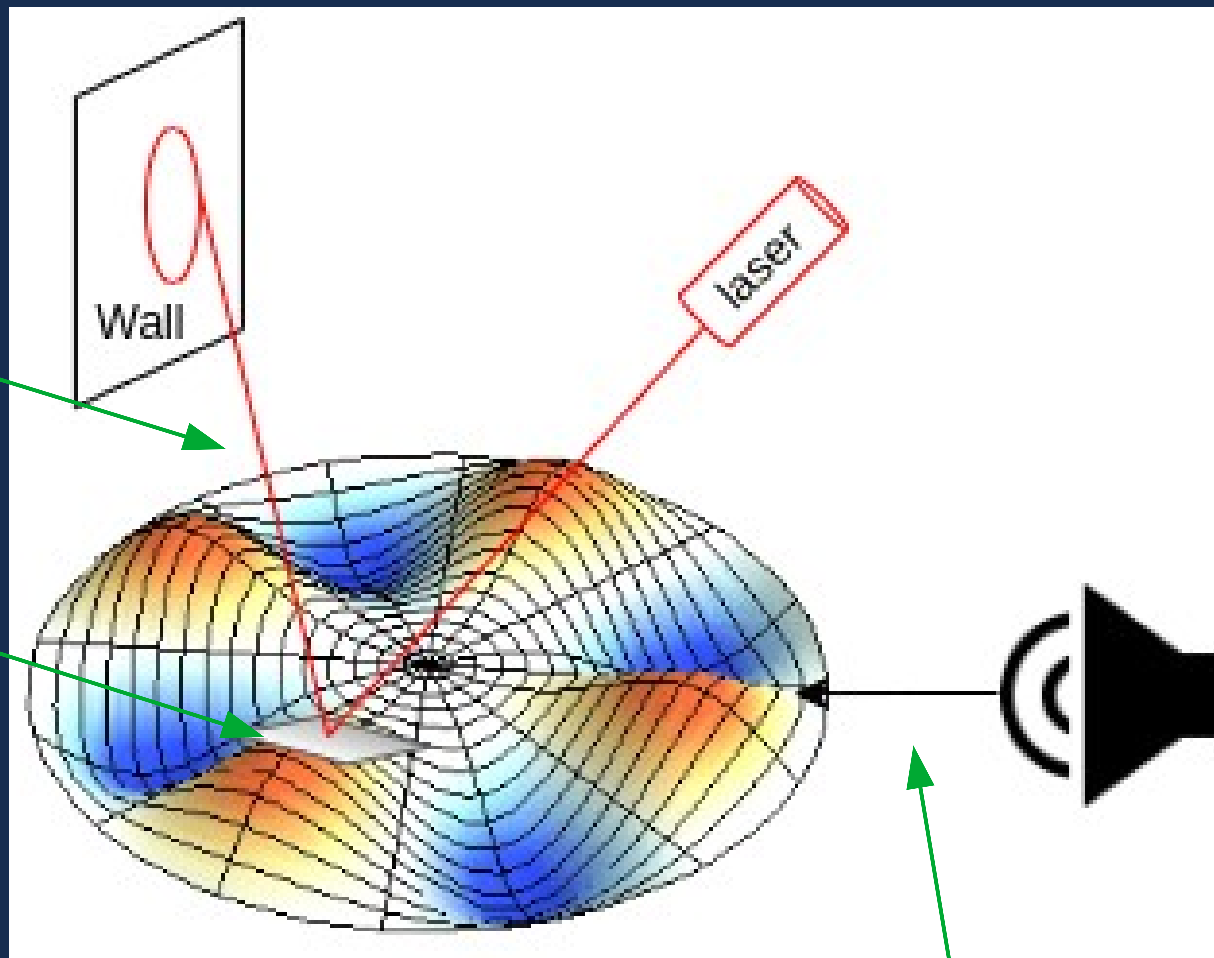
Pattern amplitudes

What determines the pattern amplitude?



(5)Distance mirror-wall

(4)Mirror location

(3)Membrane
- Resonant?
- Dampened?
- Mass: for frequency ⇧ → amplitude ⇩

(1) Sound source level

(2)Distance source-membrane

Pattern saturation

- Source: amplitude ⇧ → Pattern: amplitude ⇧ but shape should not change
- If the shape changes, there is saturation ("non-linearity"