# Akustické metamateriály s negativní tuhostí: model membránového absorbéru

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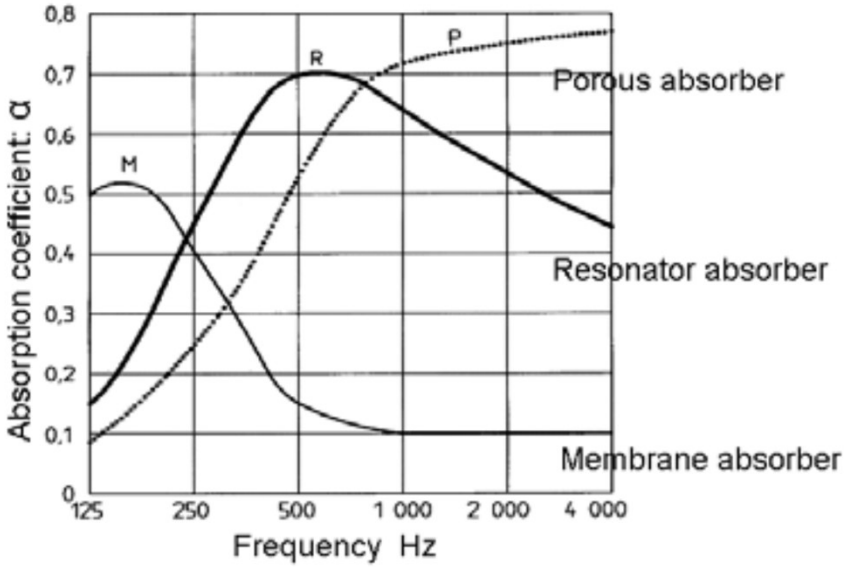
# Acoustic metamaterials (AMMs)

- Metamaterials → with properties not found naturally
- Made artificially, optimized for a specific purpose
- AMMs = influence acoustic properties
  → reacting to wavelengths similar to those of acoustic waves
- Negative stiffness - applies to an oscillating membrane
  → lowers the resonance frequency

LU, Qiangbing; ZHANG, Xiujuan; LI, Xin; LU, Minghui a CHEN, Yanfeng. *Perspective: Acoustic Metamaterials in Future Engineering*. Engineering. 2022

# Why do we want lower resonance?




JACOBSEN, Finn; POULSEN, Torben; RINDEL, Jens; GADE, Anders a OHLRICH, Mogens. *Fundamentals of Acoustics and Noise Control*. 2011.

# Membrane acoustic absorber with negative stiffness

- Membrane acoustic absorber: *acoustic energy → heat* (damped oscillation)
- Absorbed wavelength is determined by resonance frequency
- Resonance frequency of a negative stiffnes structure:

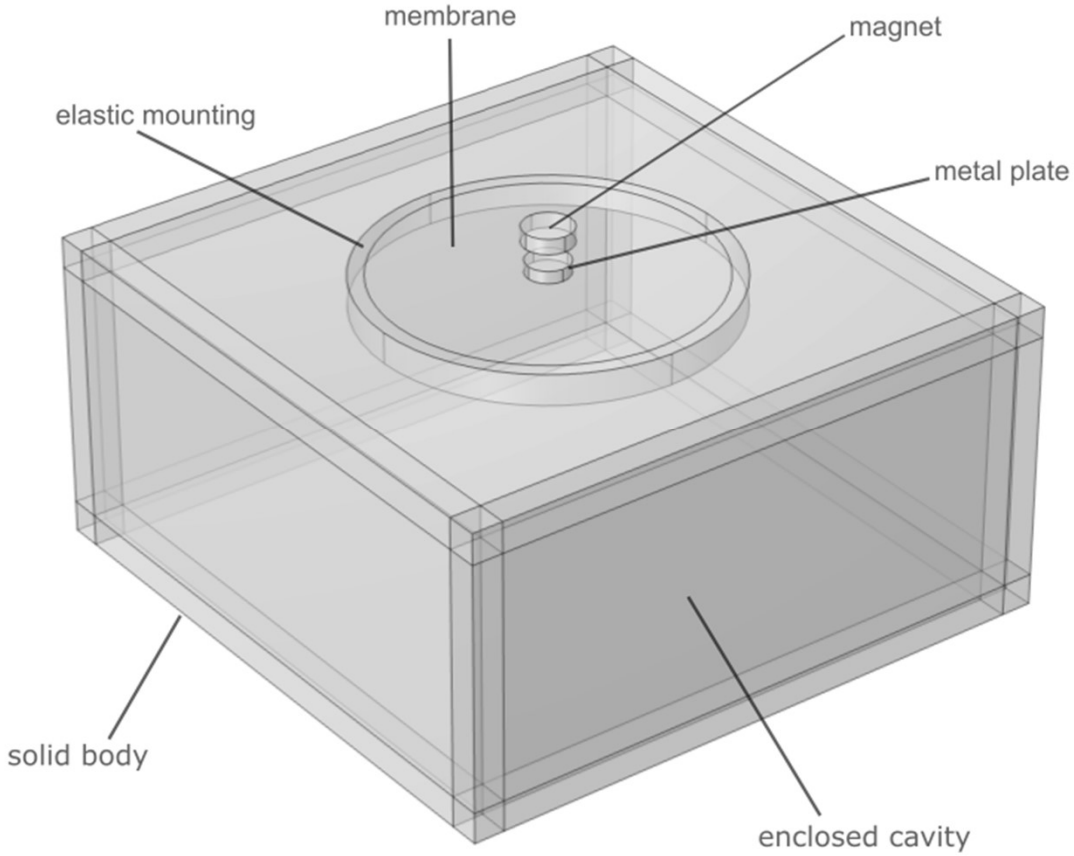
$$f_{res} = \frac{1}{2\pi}\sqrt{\left(\frac{S}{m}\right)}\rho c_0$$ ($s$ … stiffness, $m$ … surface density, $\rho$ … air density, $c_0$ … sound velocity in air)

*negative stiffness → $f_{res}$ is a complex number → real part is smaller → absorption on lower frequencies*

JUNJUAN, Zhao; LI, Xianhui; WANG, Yueyue a WANG, Wenjiang. *Bandwidth analyses of a membrane type sound absorber with magnetic negative stiffness*. 2020

JUNJUAN, Zhao; LI, Xianhui; WANG, Yueyue; WANG, Wenjiang; ZHANG, Bin et al. *Membrane acoustic metamaterial absorbers with magnetic negative stiffness.* The Journal of the Acoustical Society of America. 2017

# Membrane acoustic absorber model, geometry



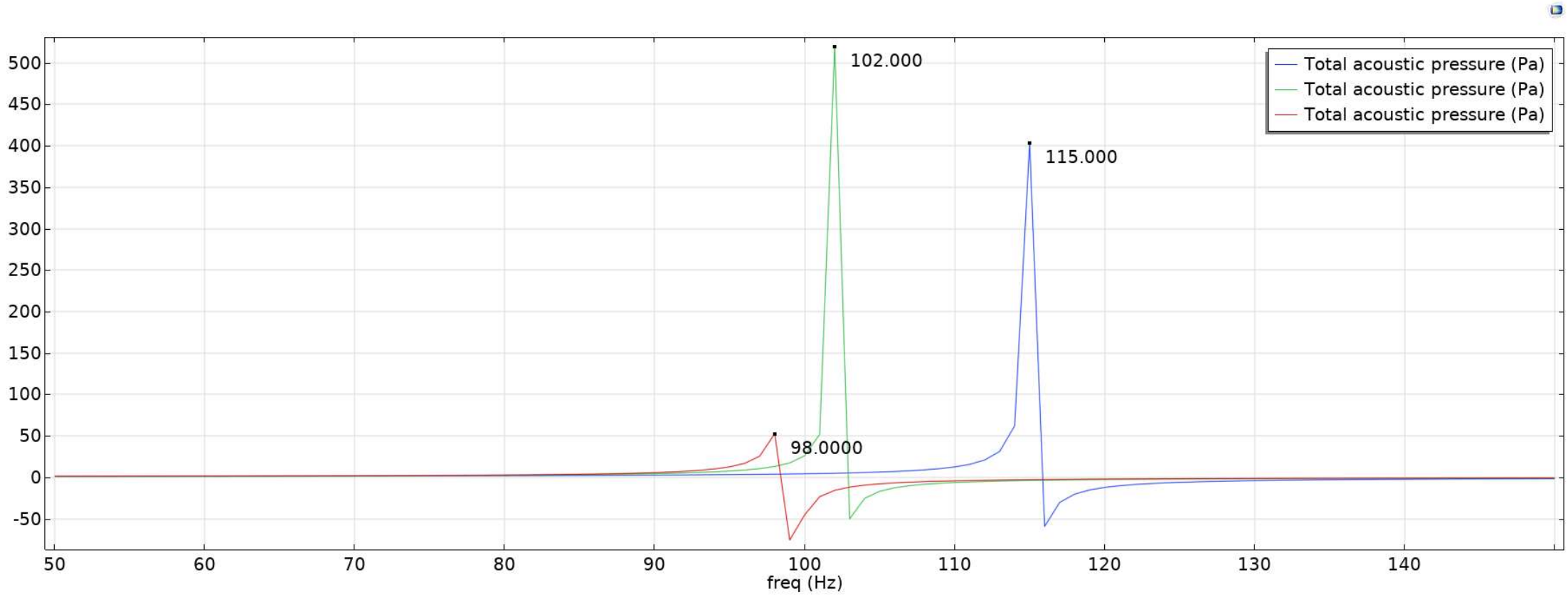
# Membrane acoustic absorber model, physics

- Pressure Acoustics, Frequency Domain
- Shell
- Magnetic Fields, No Currents
- Multiphysics

  → Acoustic – Structure boundary

Study: Stationary, Frequency-Domain Perturbation

# Results


Total acoustic pressure (Pa)
Total acoustic pressure (Pa)
Total acoustic pressure (Pa)
102.000
115.000
98.0000
500
450
400
350
300
250
200
150
100
50
0
-50
50
60
70
80
90
100
110
120
130
140
freq (Hz)