NUMERICAL MODEL TO SIMULATE THE FORWARD AND REVERSE SOUND TRANSMISSION MECHANISM IN HEARING

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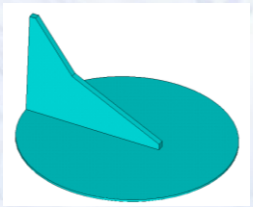
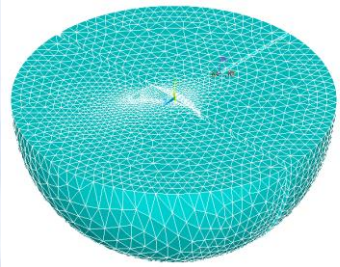
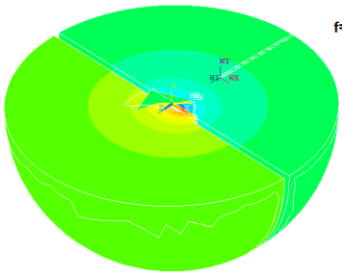
Outline







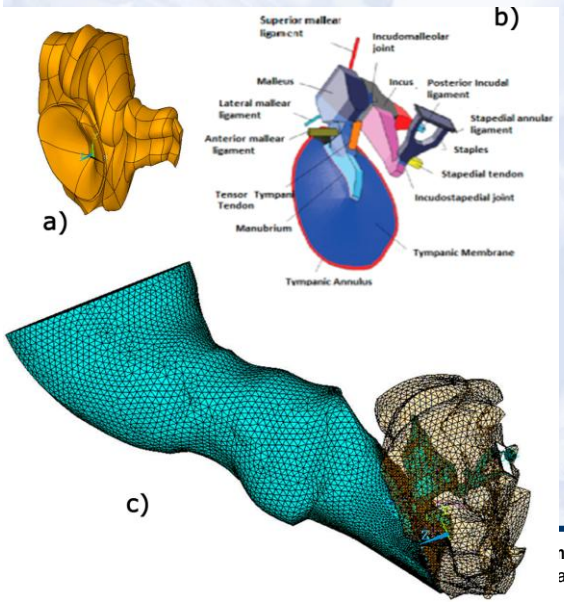
- Introduction
- Experiment
- Numerical model
- Results
- Conclusions

Numerical model to simulate the forward and reverse sound transmission mechanism in hearing
J. Camacho, J. Garcia-Manrique, A. Gonzalez-Herrera

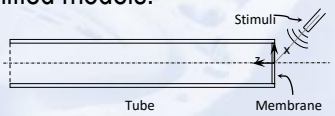
Introduction

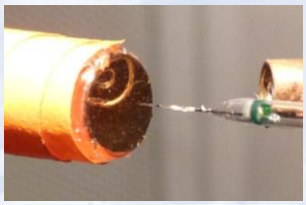
Research lines:

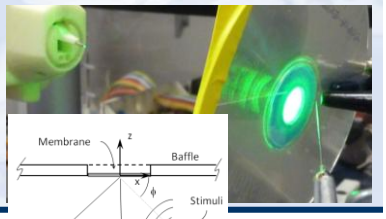
Model with high complexity:



Simplified models:







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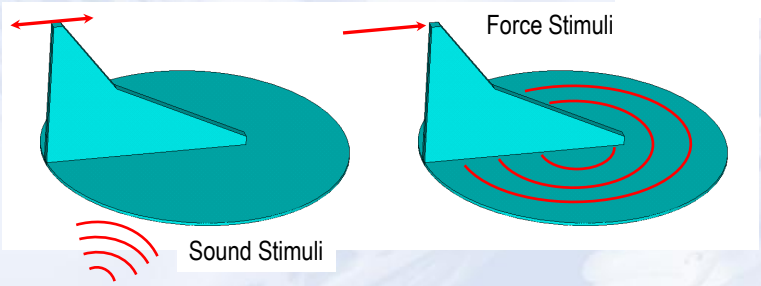
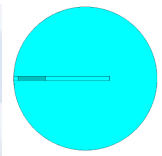
Experiment setup

Simplified experiment with the basic element:

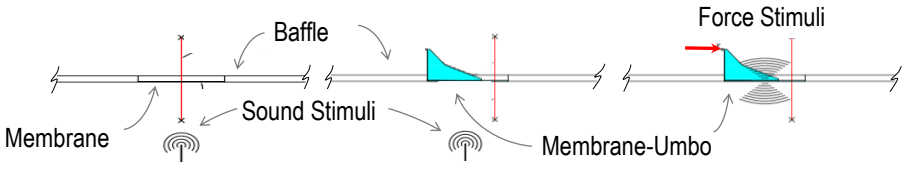
air, TM and ossicular chain

Forward **Reverse**





Membrane **Membrane-Umbo Forward** **Membrane-Umbo Reverse**



Numerical Model

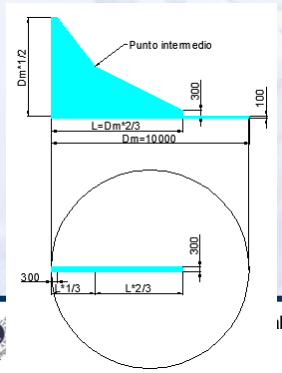
Dimensions

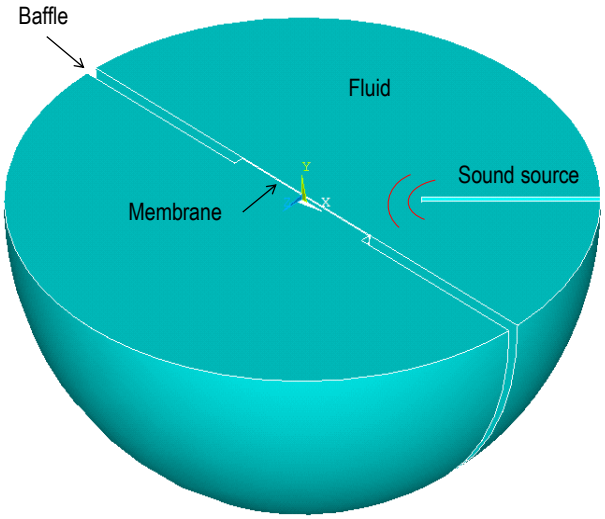
Membrane:

- Diameter: 1cm
- Thickness: 100 μm
- Umbo: 2/3 diameter

Material properties ABS:

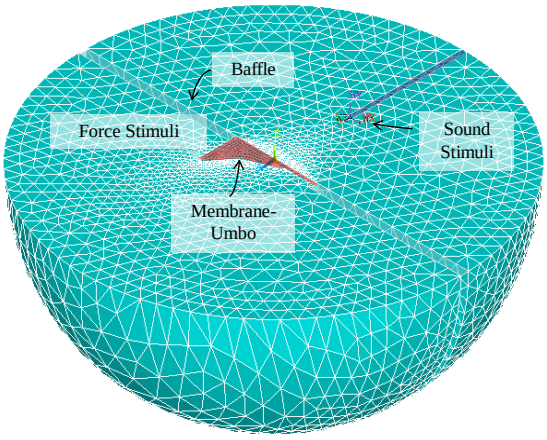
- E = 2 Gpa; υ = 0.35
- ρ = 1200 kg/m^3

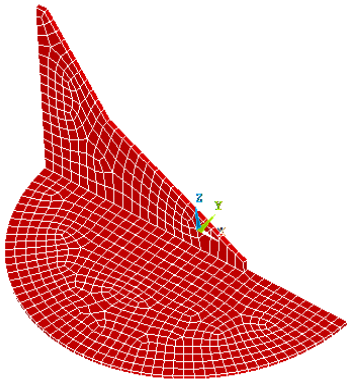




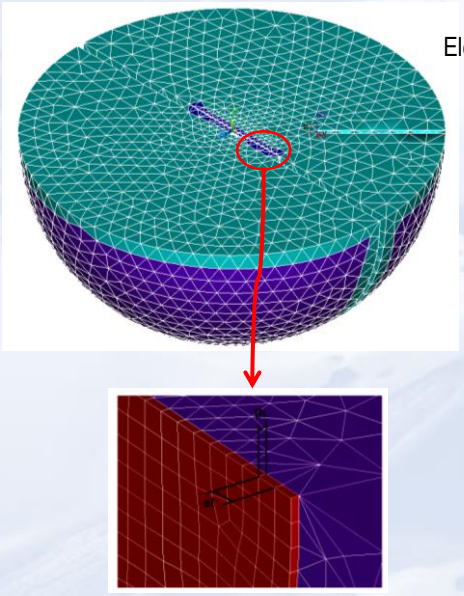
Numerical Model

Finite Element Model





Numerical Model



Element size:

- Fluid: based on the wave length

λ=v/f = 340(m/s)/20000(Hz)=0,017 m =17mm

λ/10 = 1.7mm

- Solid: based on previous studies*, in terms of the membrane thickness

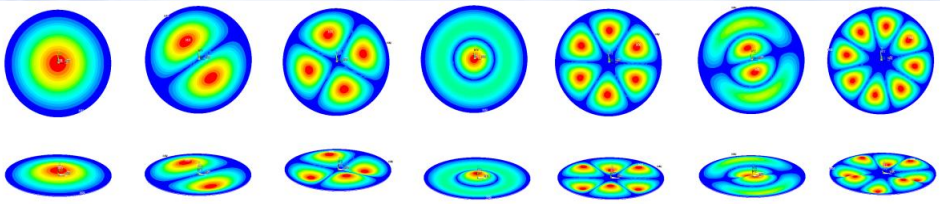
maximum element size = Thickness*10 = 1mm

*A. Gonzalez-Herrera, E.S. Olson, A study of sound transmission in an abstract middle ear using physical and finite element models, J. Acoust. Soc. Am. 138 (2015) 2972–2985

Results

Membrane:

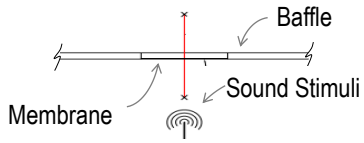
Modal Analysis (kHz):

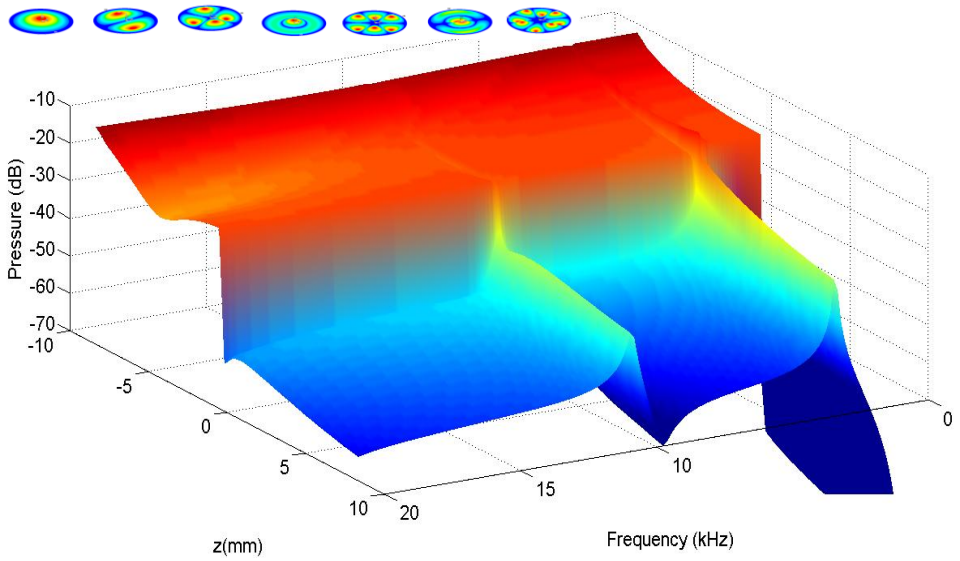


mode	1	2	3	4	5	6	7	8	9	10
Membrane	2.56	5.33	8.78	10.1	12.8	15.4	17.5	21.5	22.7	28.2

Results

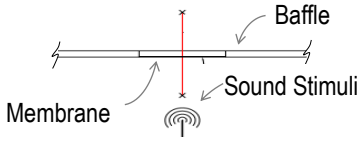
Membrane:
Sound Pressure

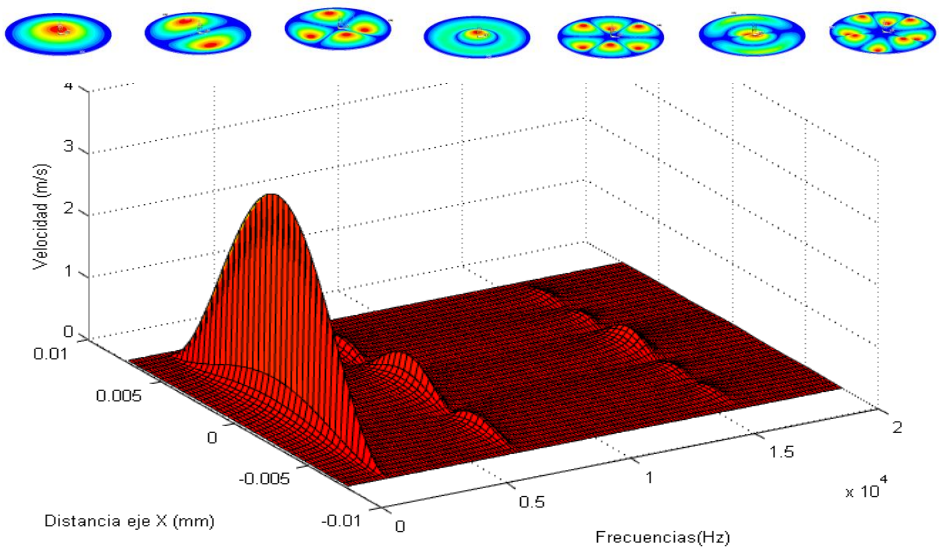




Results

Membrane:
Velocity

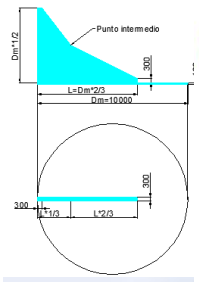


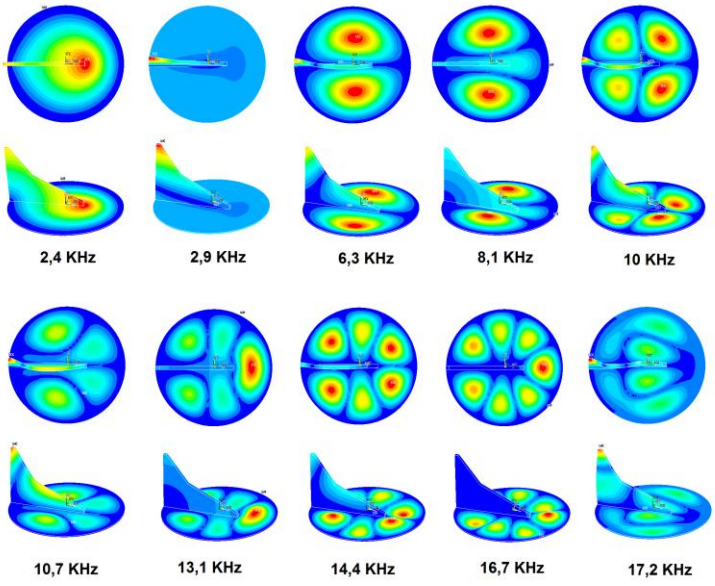


Results

Membrane-Umbo:

Modal Analysis:





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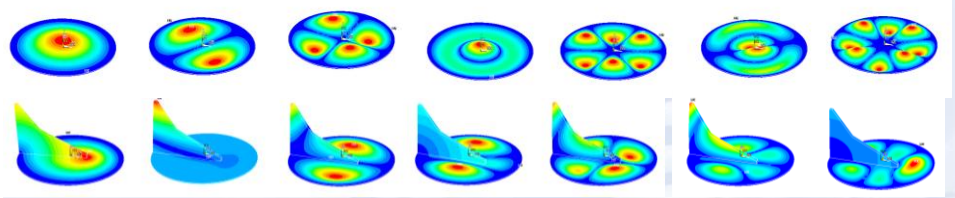
Results

Comparison:

Modal Analysis:



Mode 1 Mode 2 Mode 3 Mode 4 Mode 5 Mode 6 Mode 7

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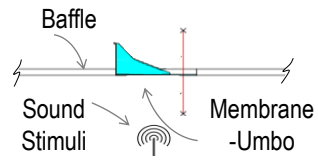
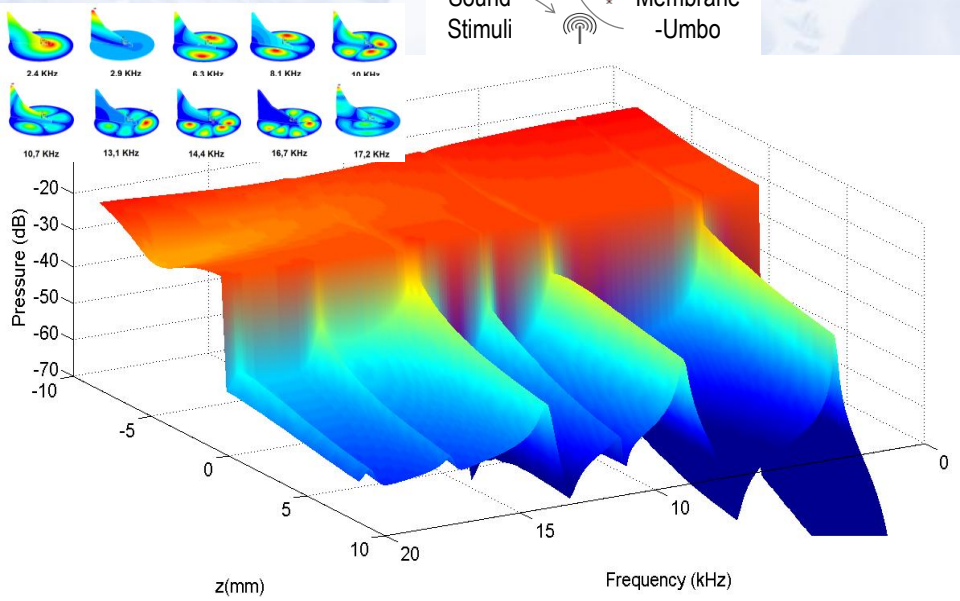
Membrane-Umbo	2.4	2.9	6.3	8.1	10	10.7	13.1	14.4	16.7	17.2

Results

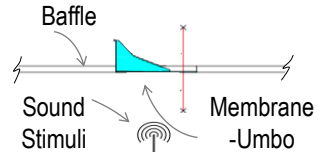
Membrane-Umbo, Forward:
Sound Pressure

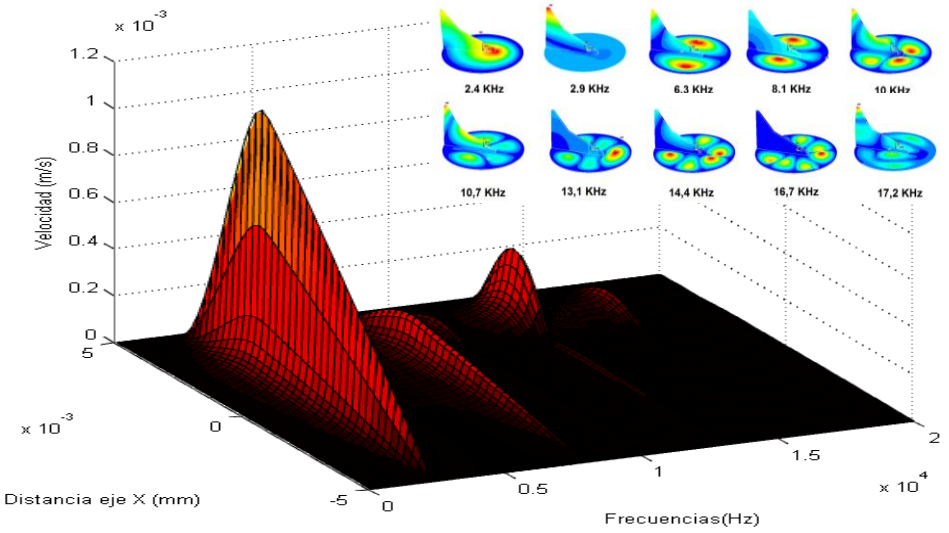




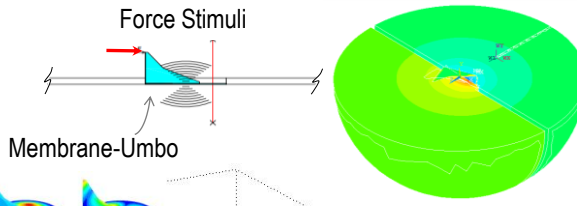
Results

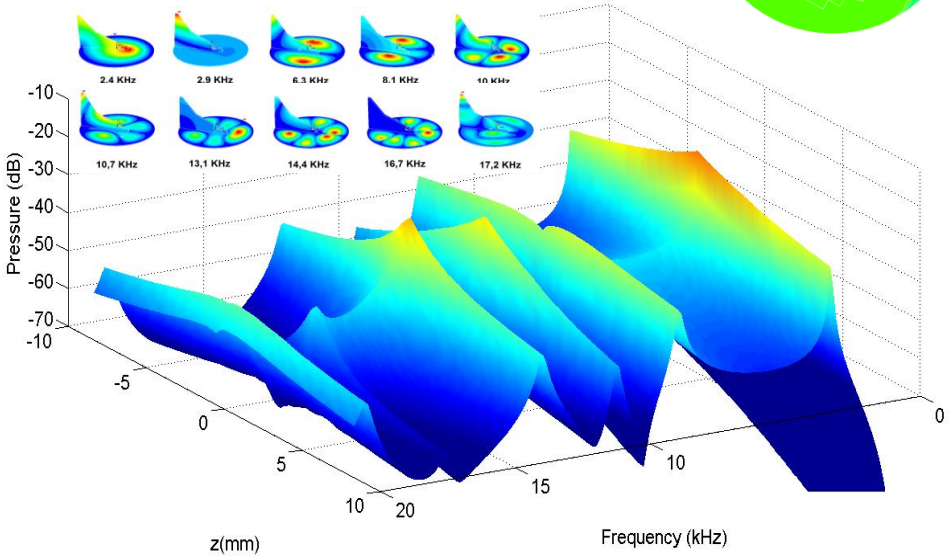
Membrane-Umbo, Forward:
Velocity



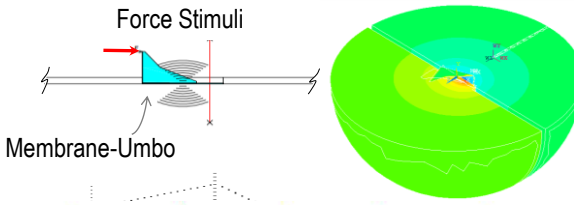


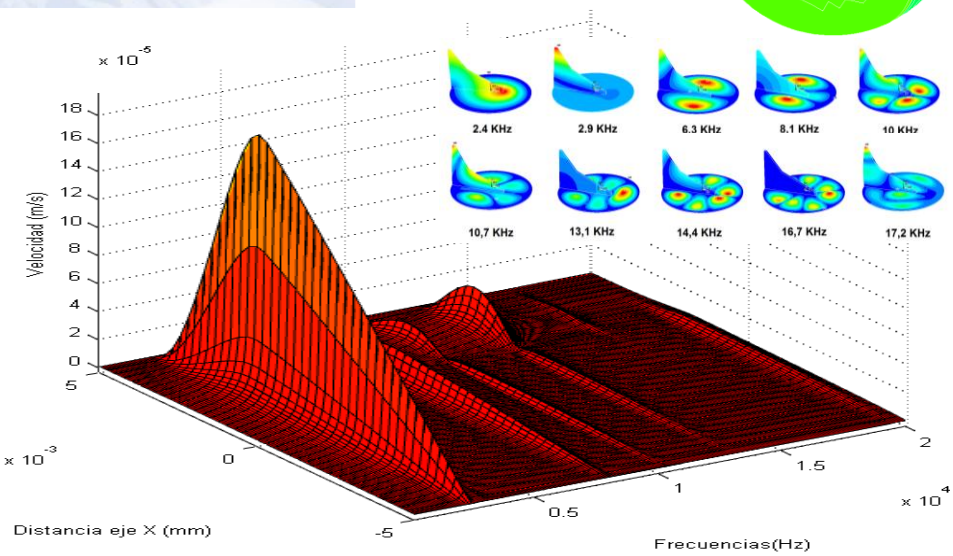
Membrane-Umbo, Reverse: Sound Pressure



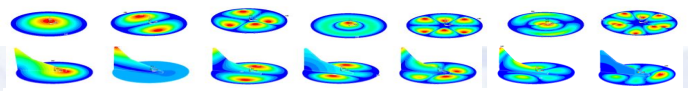


Membrane-Umbo, Reverse: Velocity





Comparison: Sound Pressure



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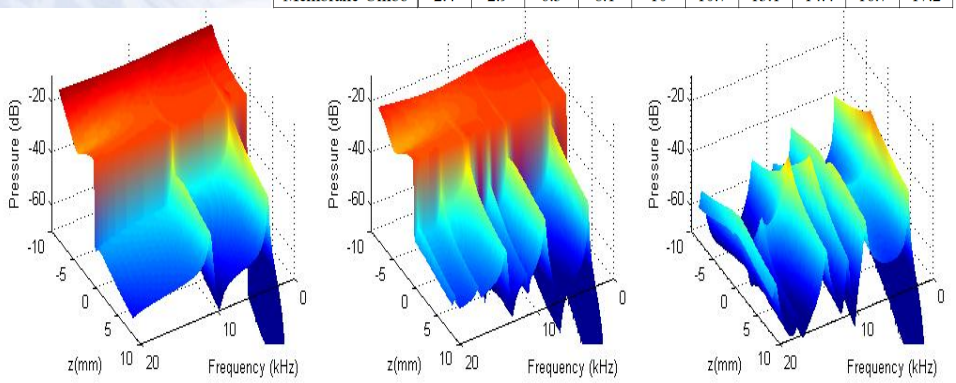
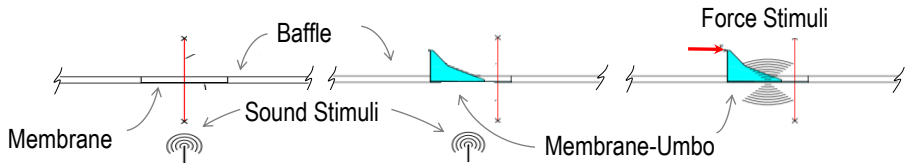
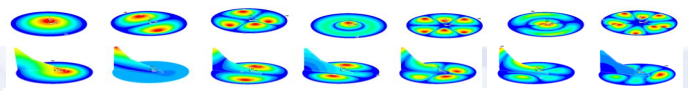




Comparison: Velocity



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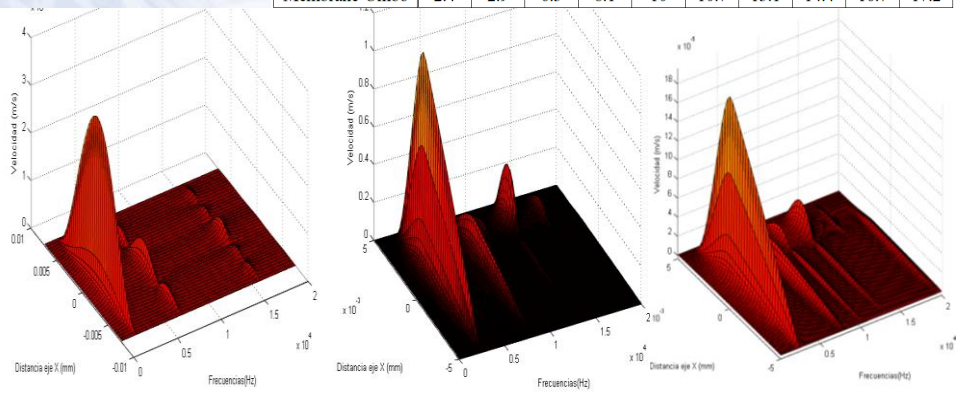

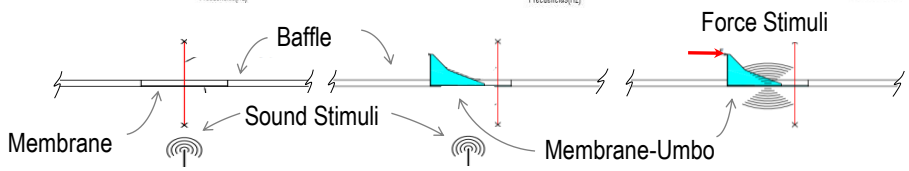

Conclusions

A simplified numerical model to simulate the forward and reverse sound transmission mechanism has been build.

This model will be used to adjust proper dimensions to facilitate the experiment.

- The presence of the umbo adds stiffness and mass to the system.
- The effect of the mass is more significant, increasing the number of modes present in the range of frequency of interest.
- Comparing forward and reverse mechanisms the main difference is in the response on the side of the membrane where the stimuli is present