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Lamb Waves in Fluid-Loaded Plates

24.10.2013

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COMSOL
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Outline

Lamb waves

Generation and properties

Dispersion curve calculation using Comsol

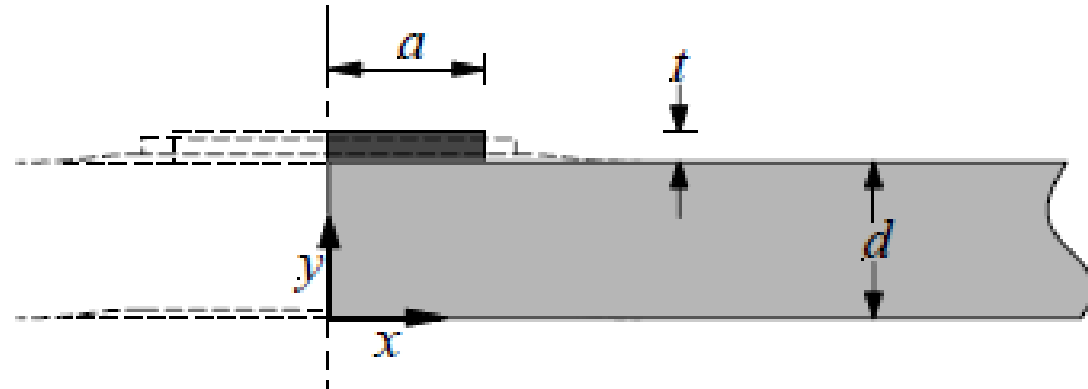
Time-dependent vs. eigenfrequency approach

Equation-based modeling description for fluid

Experimental validation and conclusions

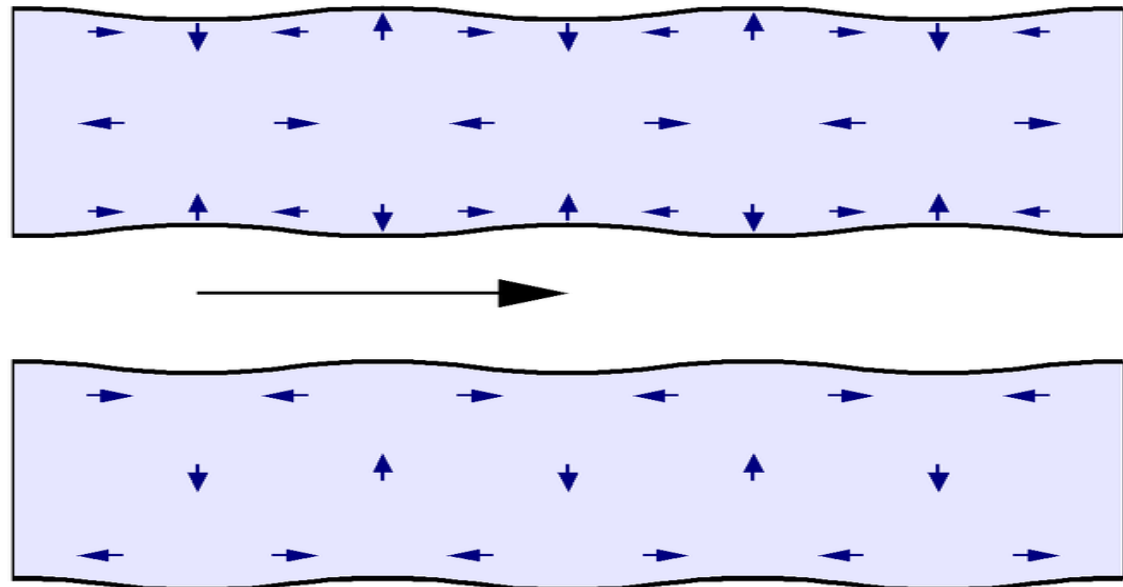
Lamb waves – elastic waves in solid plates

Generation and detection with piezo transducers



Lamb waves:

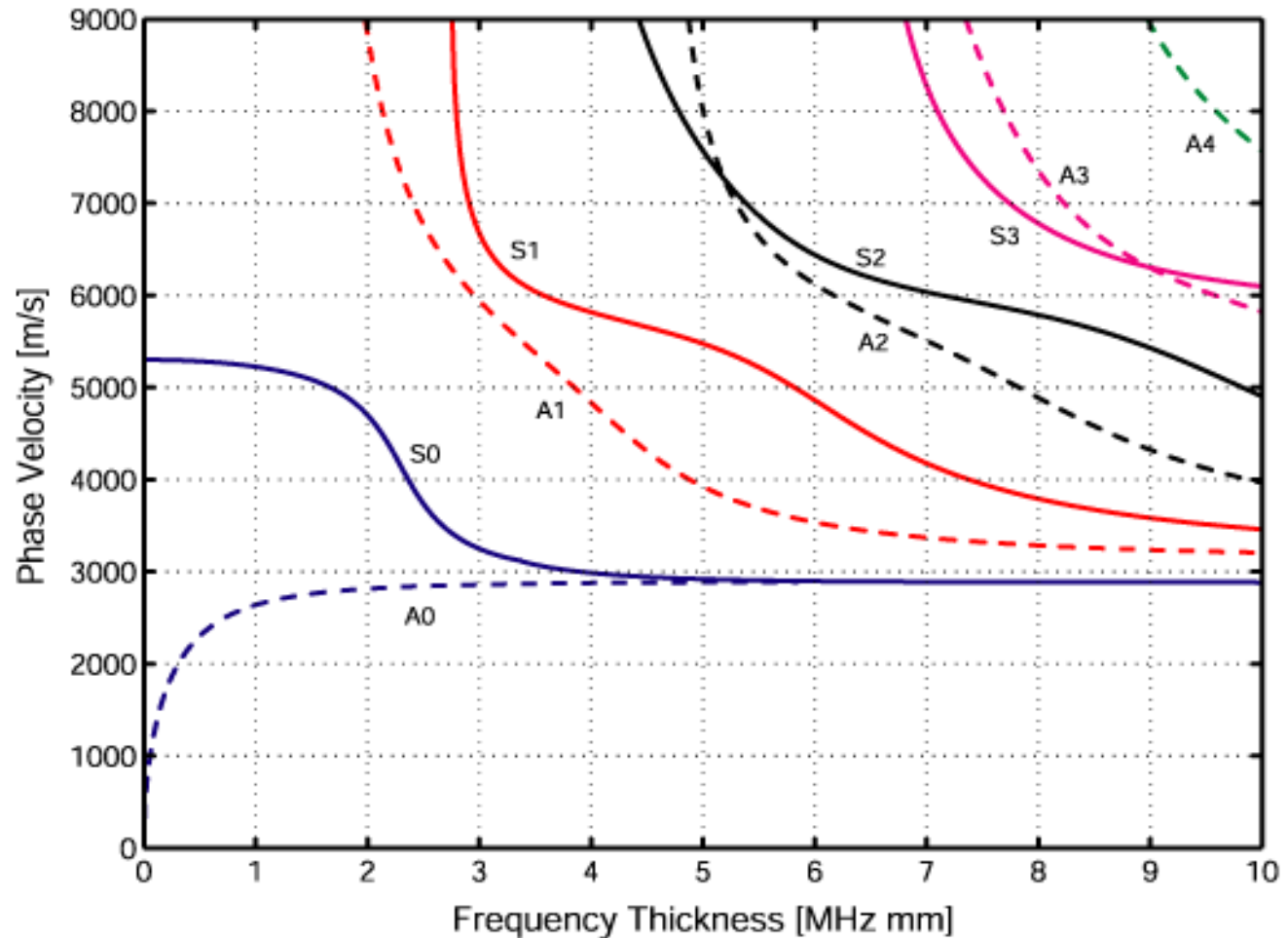
plate displacements
parallel and normal to
plate



Lamb waves

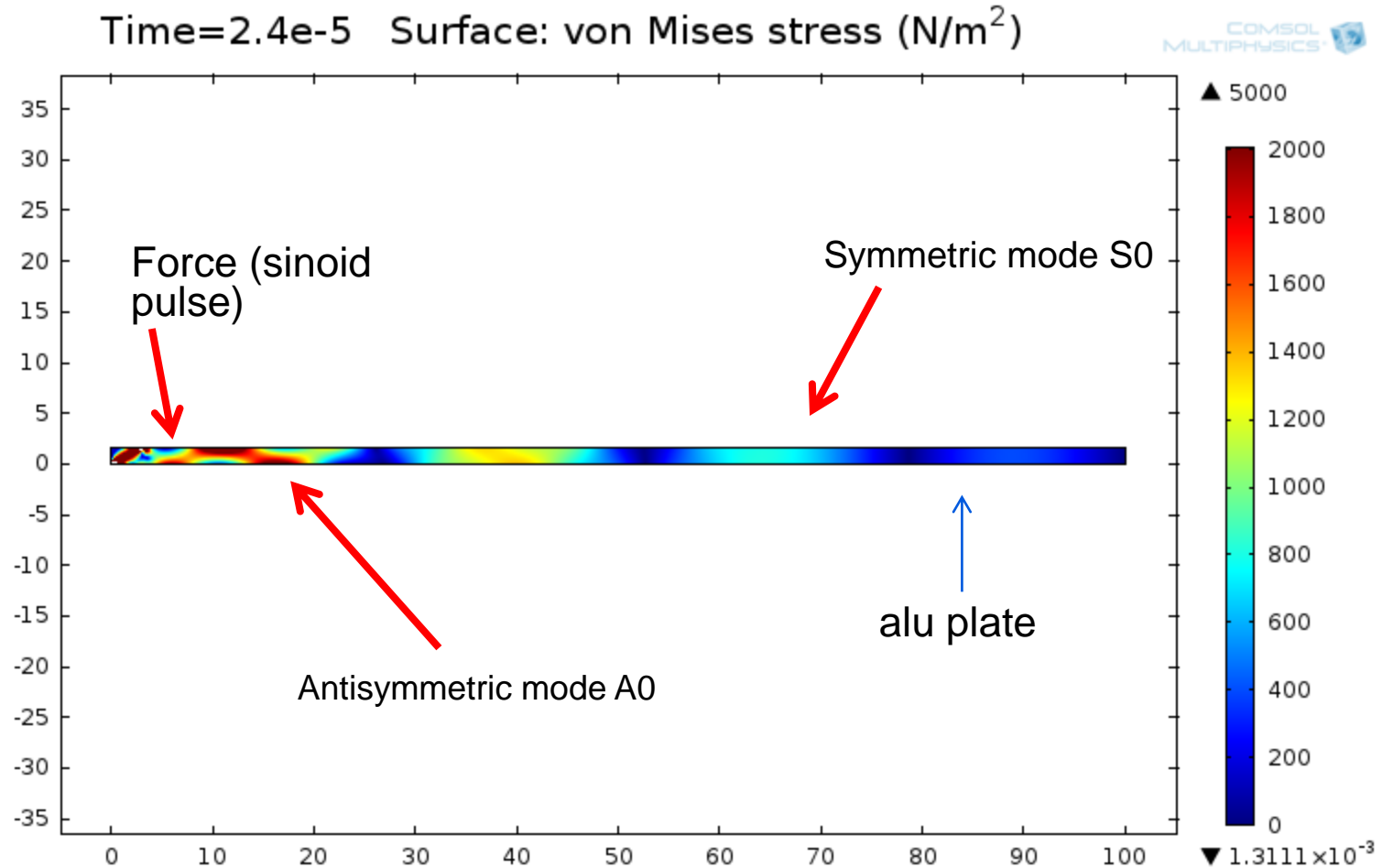
Velocity dispersion

- Two families of modes:
- symmetric
 - antisymmetric



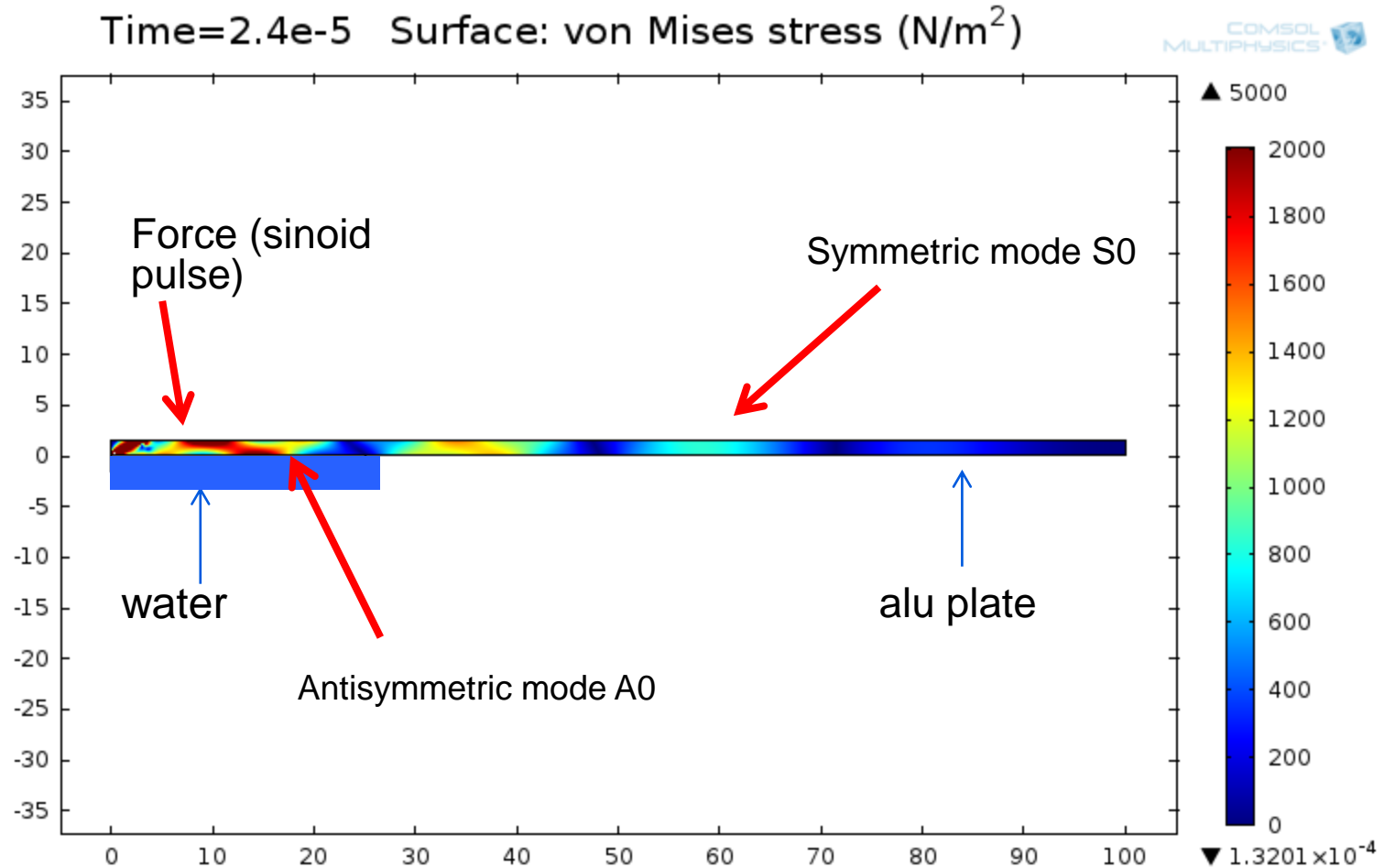
Lamb waves: free plate

2D Comsol time-dependent simulation



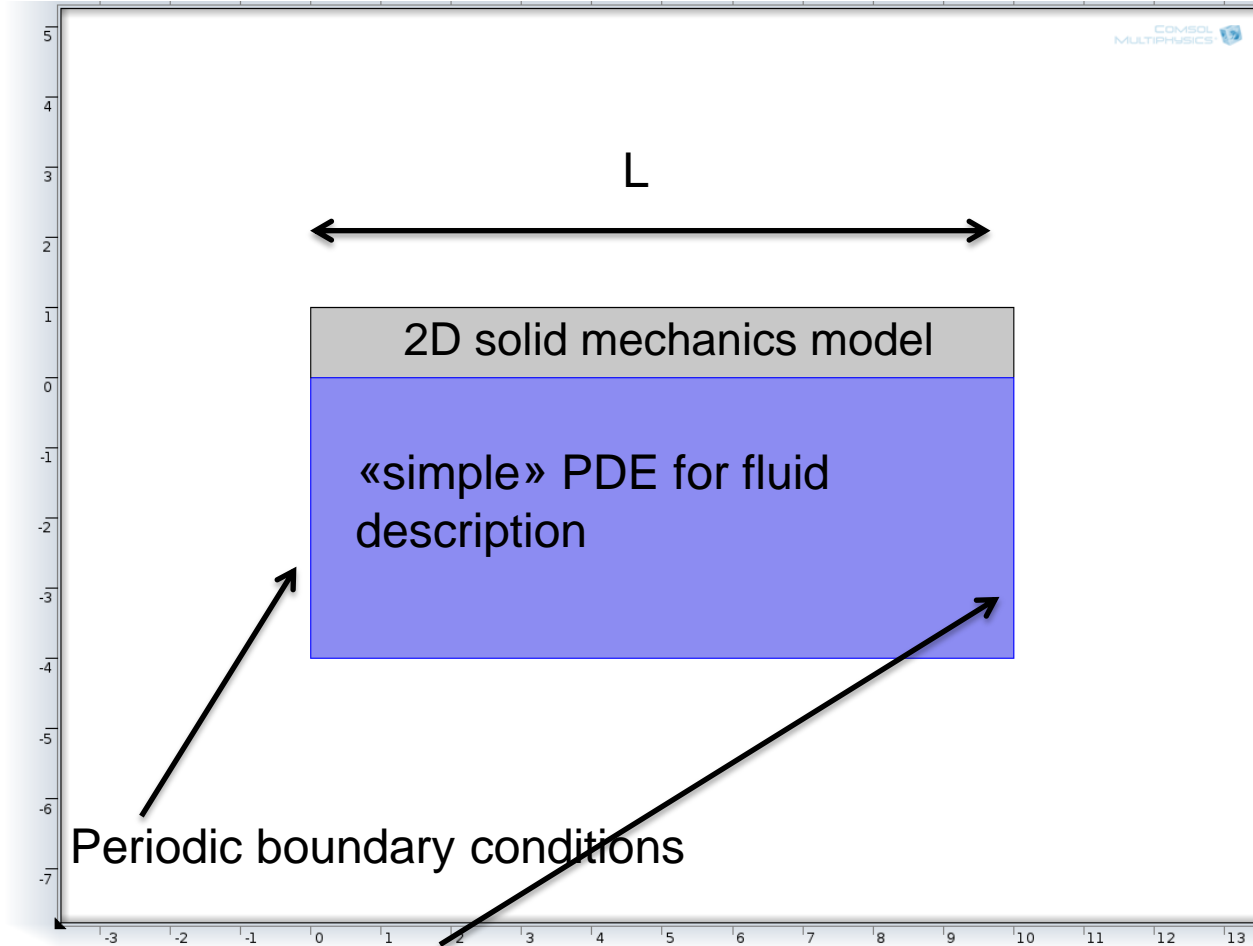
Lamb waves: plate loaded with fluid

2D Comsol time-dependent simulation

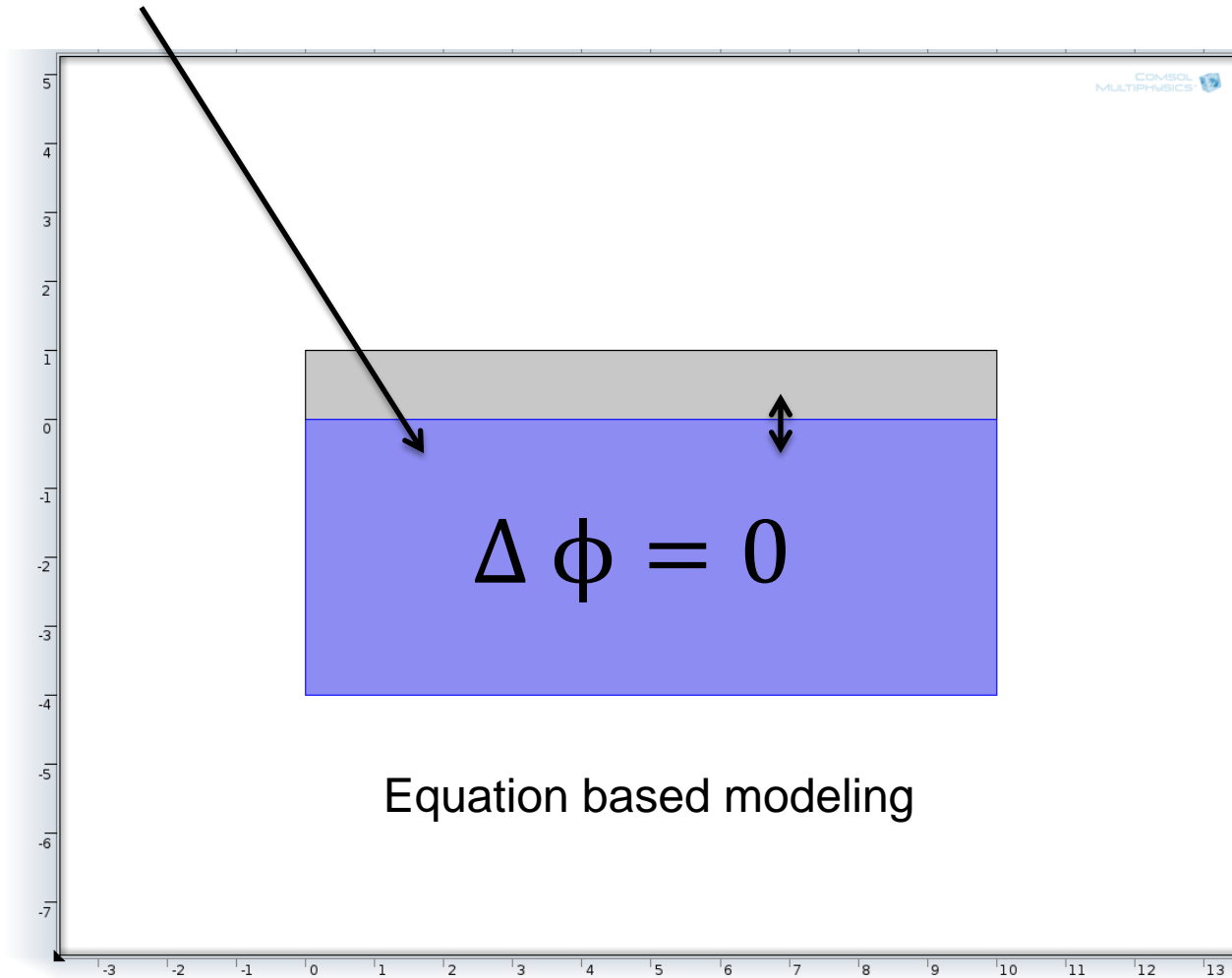


Lamb waves: plate loaded with fluid

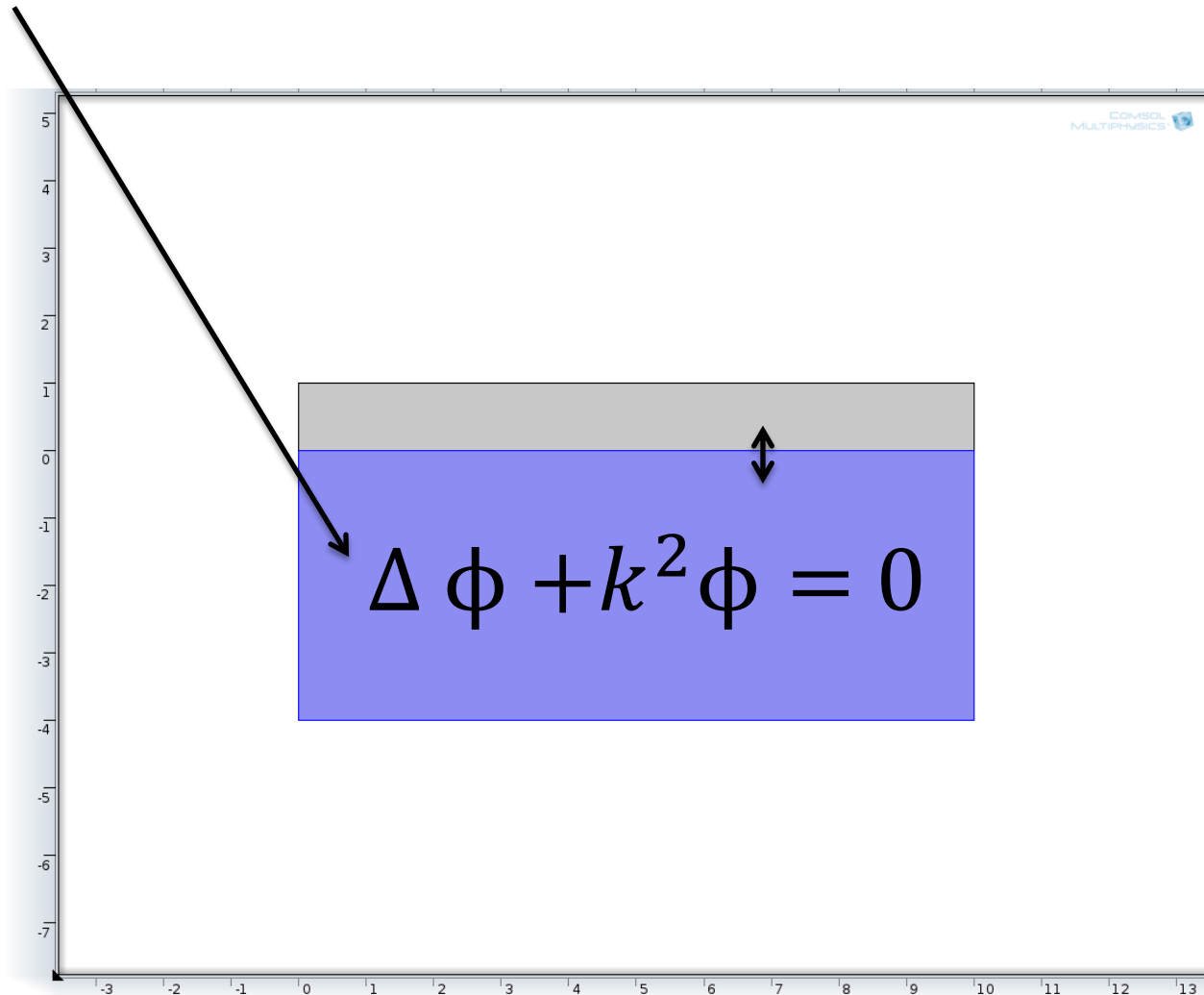
Eigenfrequency calculation, parameterized plate length L



Fluid described as incompressible and irrotational Laplace equation (as in Landau/Lifshitz)

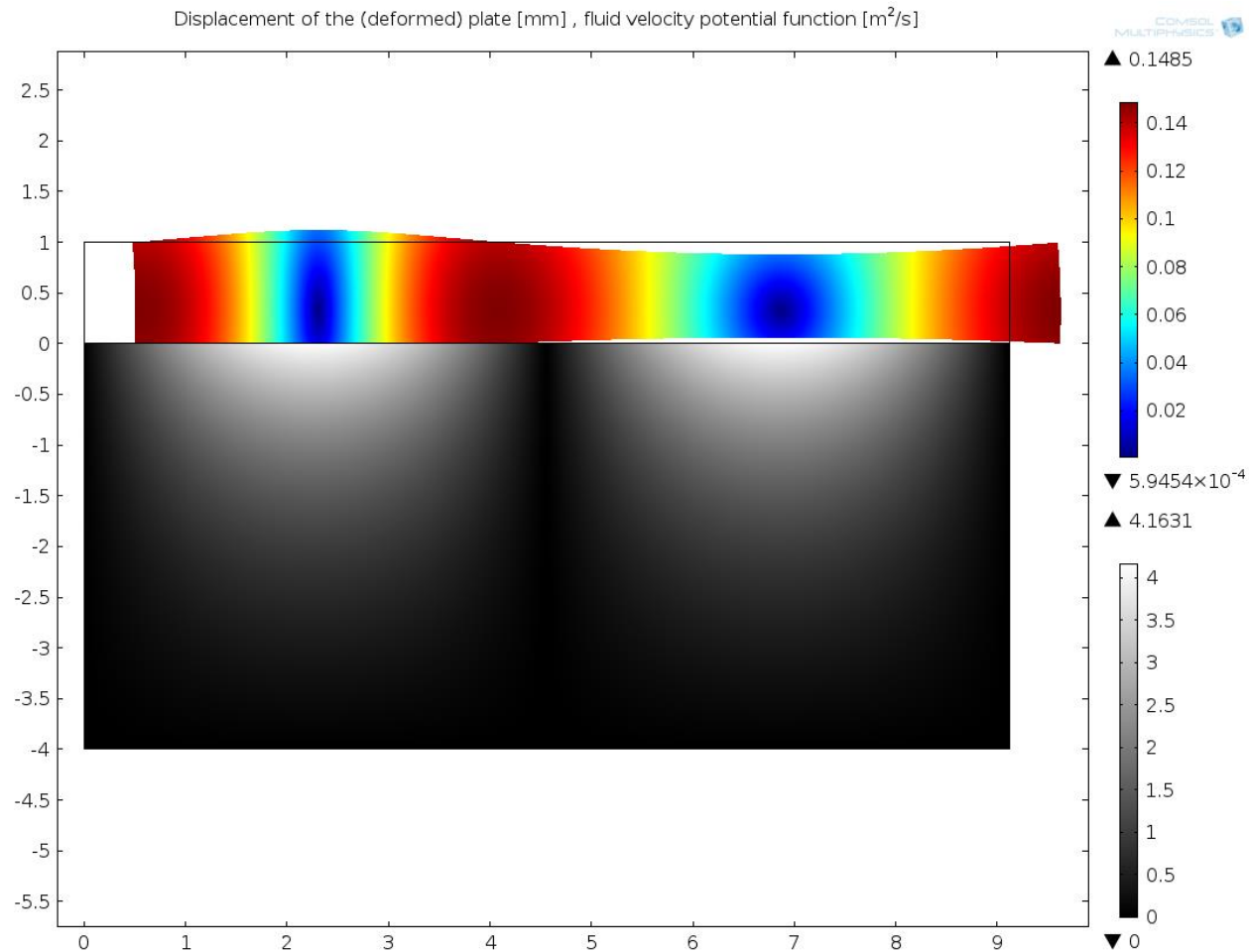


Fluid allowed to be compressible and rotational Helmholtz equation (as in Wu & Zhu 1992)

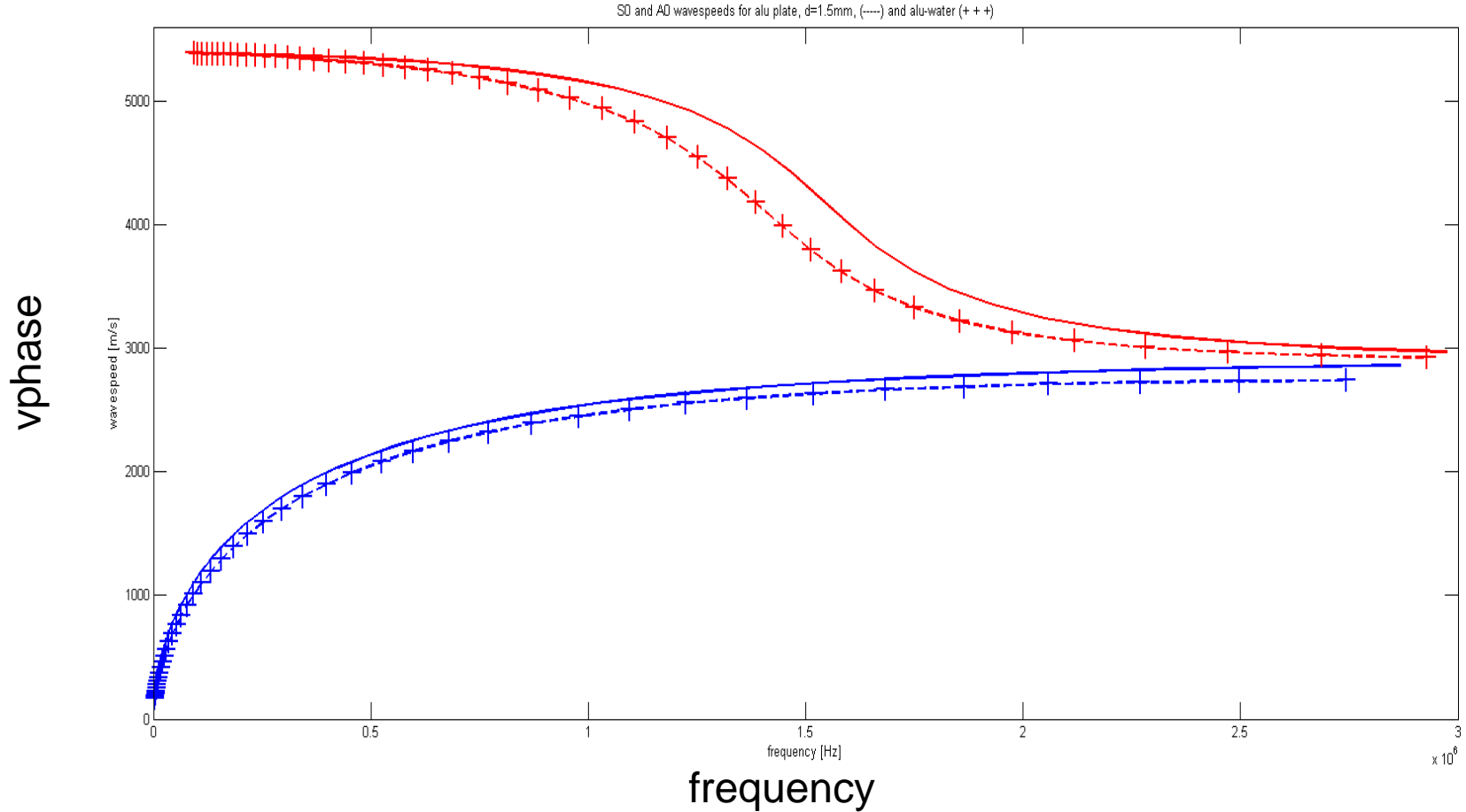


Lamb waves: plate loaded with fluid

Solution: one eigenmode shown (for Laplace eq.)



Dispersion curves for free plate and plate - water S0, A0 modes calculated with comsol, Laplace eq.



Experimental verification with alu plate

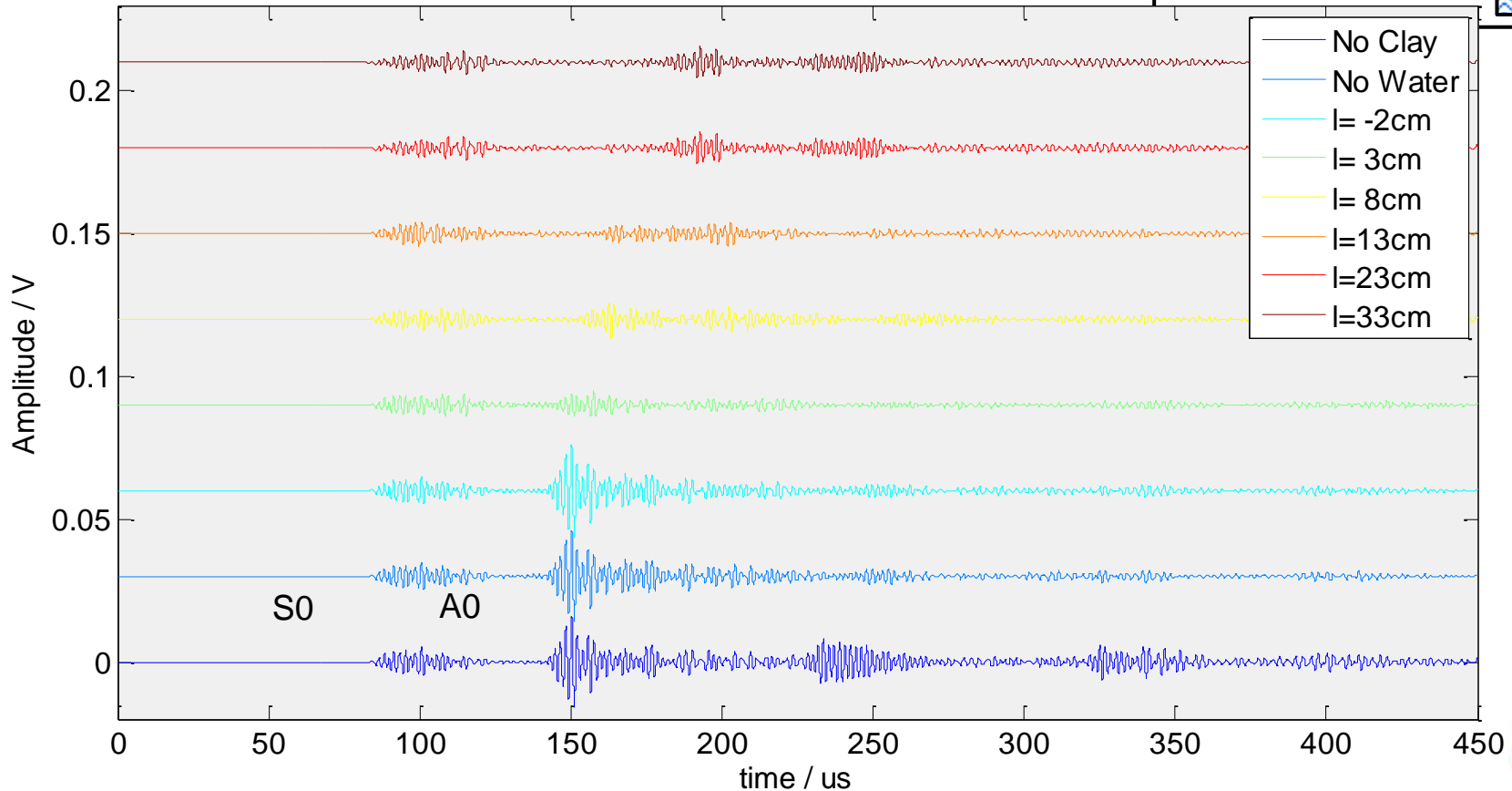
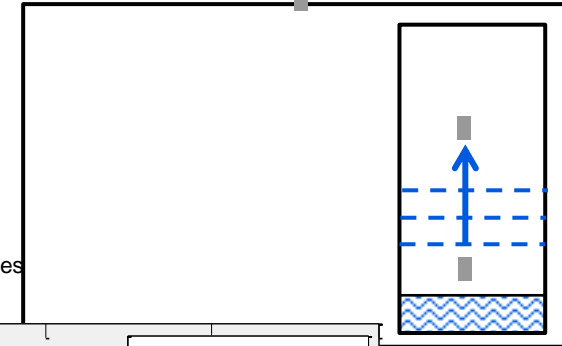
Pulse generation & detection with piezo transducers



Excitation: 2 Sinusperiods, 540 kHz, $10V_{pp}$

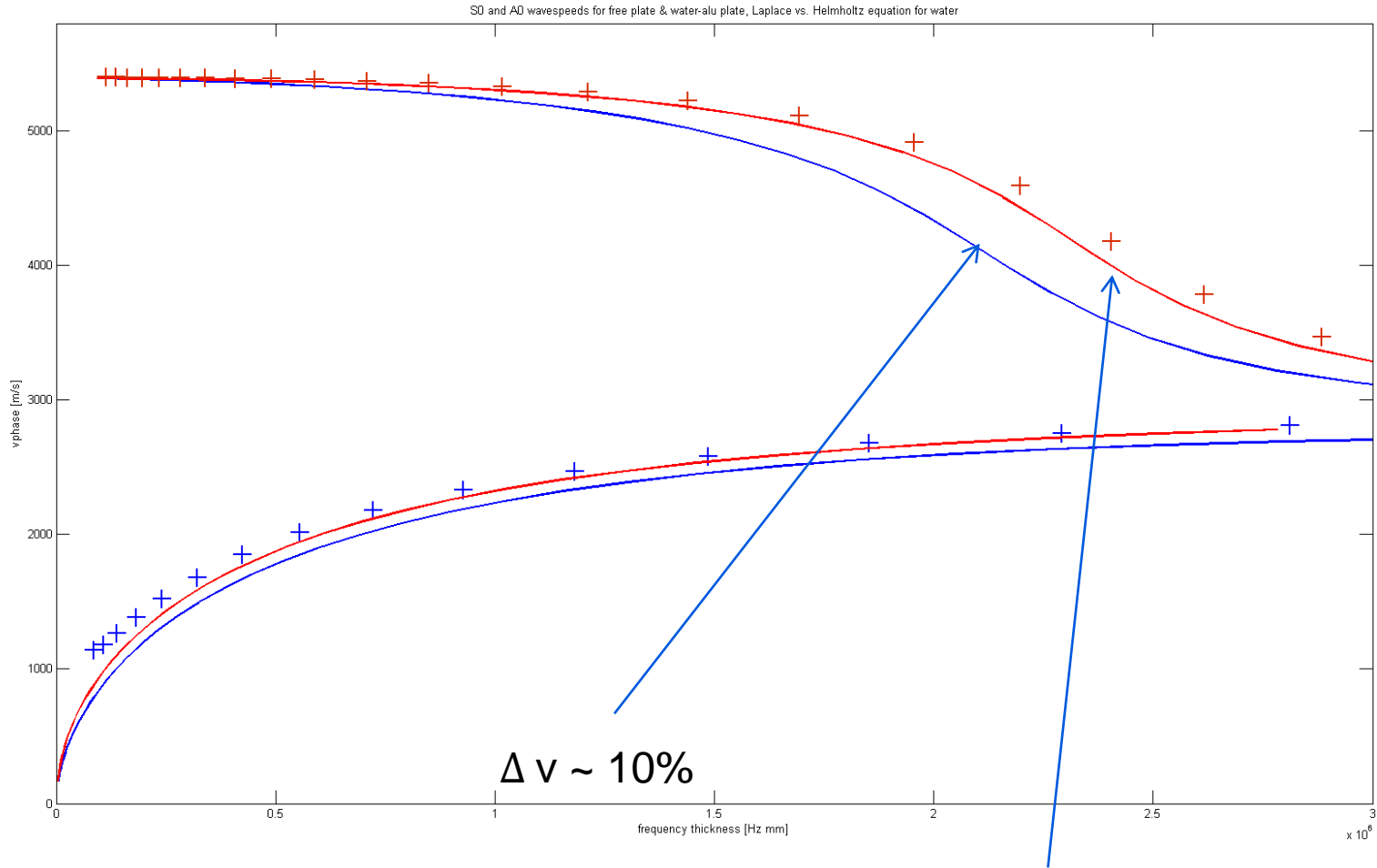
Piezo 1 → Piezo 2, Distance 0.45m, Piezos on backside, Different water sizes

Receiving: 540 kHz bandpass filter



Vphase – frequency plot

Compressible vs. incompressible & irrotational flow



$\Delta v \sim 2\%$

Conclusions

Comsol allowed the calculation of dispersion curves for coupled plate-liquid system

Fluid model critical for correct results

The use of Comsol helped understanding the complex physics of the system

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