Data processing – directional and modal filtering

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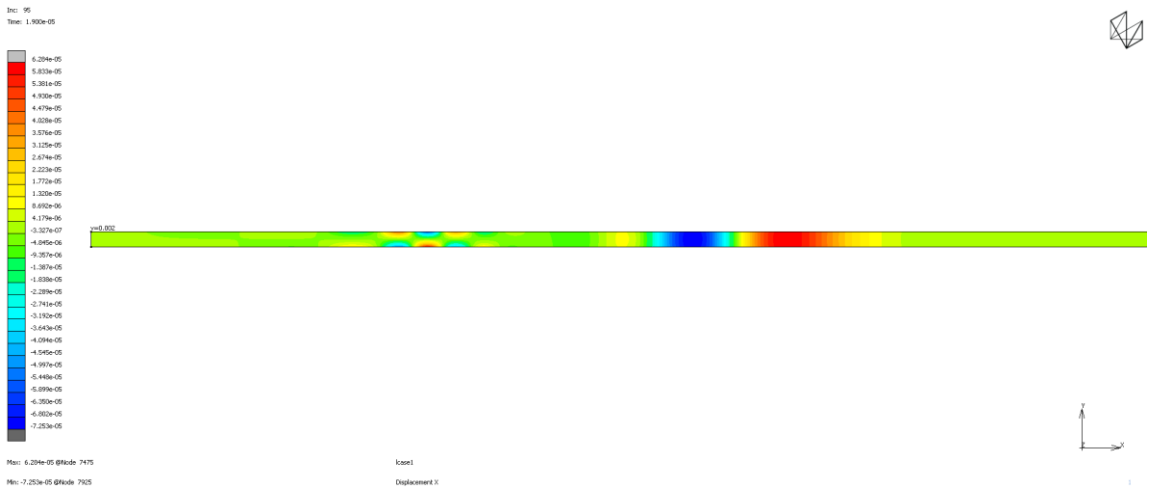
The subsequent tasks are closely related to the information presented in the lecture. The laboratory's current research agenda prioritizes the development and implementation of directional and modal filters for the analysis of measured data. A solid understanding of the methods and techniques from previous classes on efficiently running simple transient simulations is essential.

A virtual experiment should be conducted, and measurement data should be collected using the MSC Marc program or an alternative program deemed appropriate.

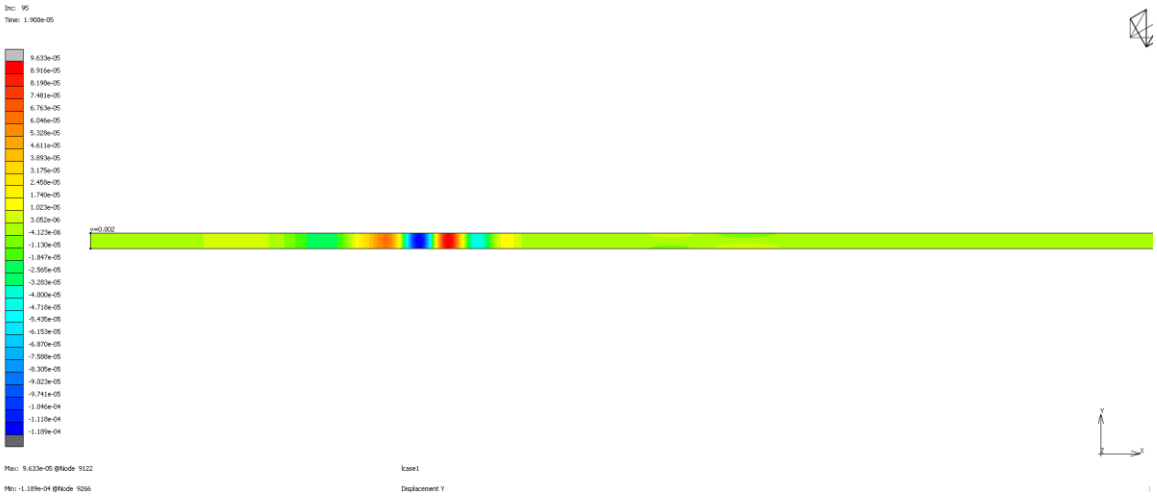
Test case no. 1

1. Create a 2D rectangular plate with dimensions of 300 x 2 mm. Specify the material properties for aluminum. Use 8 elements to discretize the plate thickness.
2. Apply an in-plane excitation signal to the upper left corner. The signal should have a center frequency of 300 kHz, a sampling frequency of 10 MHz, and consist of one cycle. Multiply the sine wave by a Hanning window to mitigate discontinuities. In the load case, use a constant time step of 0.2 µs.
3. Run your simulation for 0.1 ms and compare elastic wave propagation in **out-of-plane** and **in-plane** directions

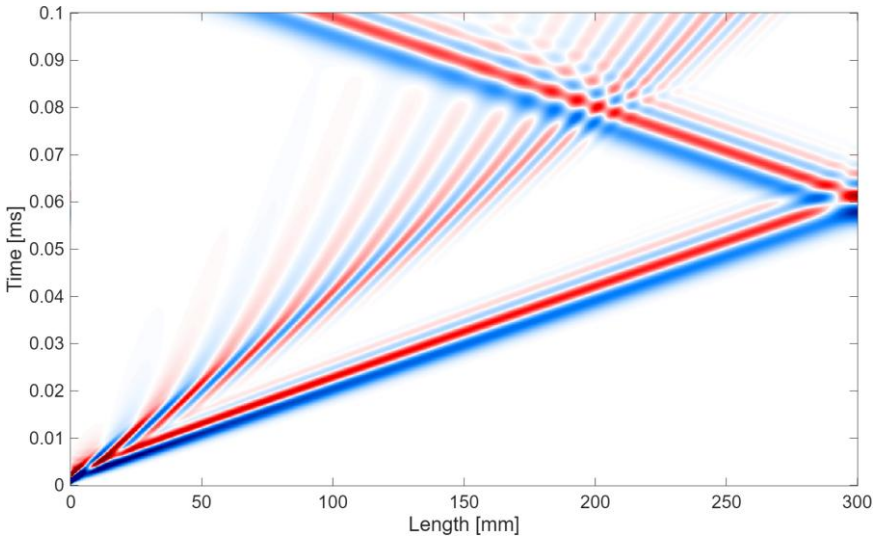
In-plane



Out-of-plane



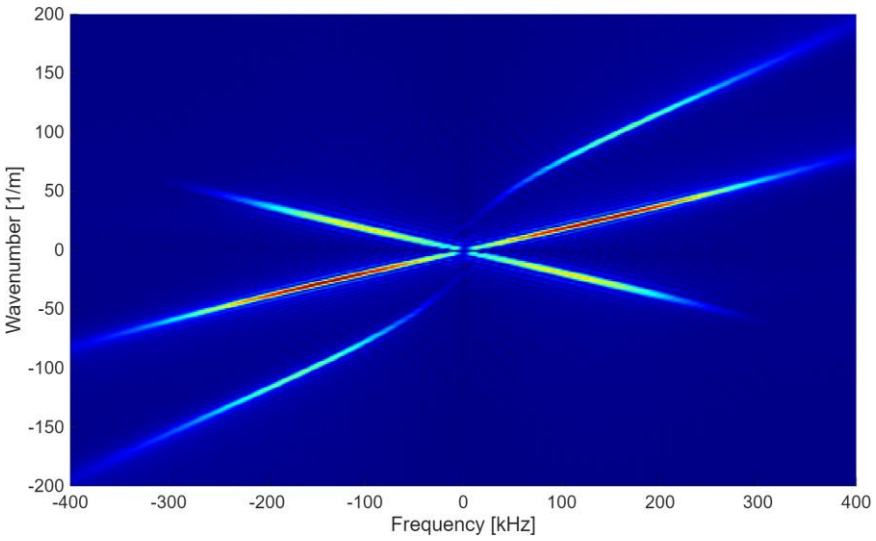
4. Collect wave motion data in the in-plane direction from the top surface of the model. Import the data into a .TXT file and plot it in MATLAB as a 2D map (space vs time). Sample results for particle displacement measured in the in-plane direction (Displacement X) are shown in the figure below.



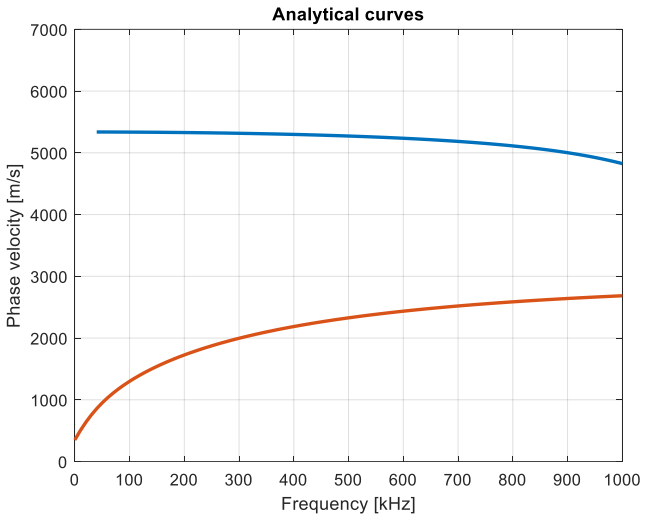
5. Based on the 2D wave motion data calculate dispersion curves using the following formula

$$U(k,f) = \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} u(x,t) e^{i(2\pi f t - kx)} dx dt$$

The final dispersion curves, ***U(k,f)***, for displacement X should resemble the figure below.

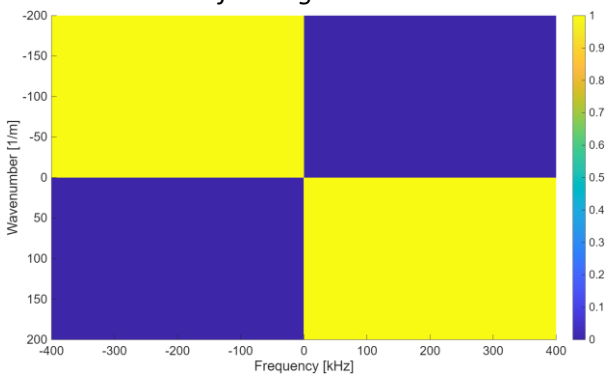


6. Based on the wavenumber-frequency plot, calculate the Lamb wave phase velocity for visible modes. Validate your results with analytical dispersion curves presented below.

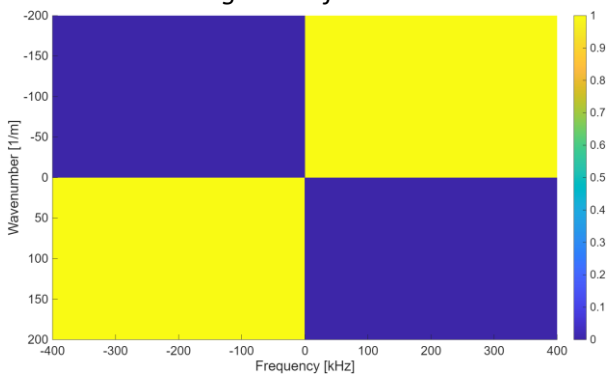


7. In the frequency domain, construct a direction filter (mask, which we can call ***m(k,f)***) to filter out left-to-right and right-to-left waves.

left-to-right mask



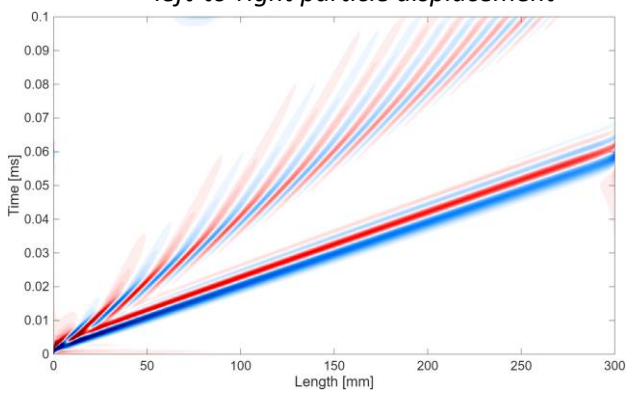
right-to-left mask



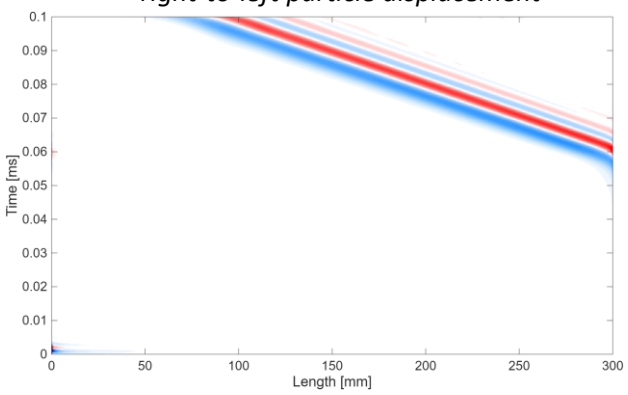
U'(k,f) = U(k,f) * m(k,f)

The resulting displacement profile after filtering should resemble the following:

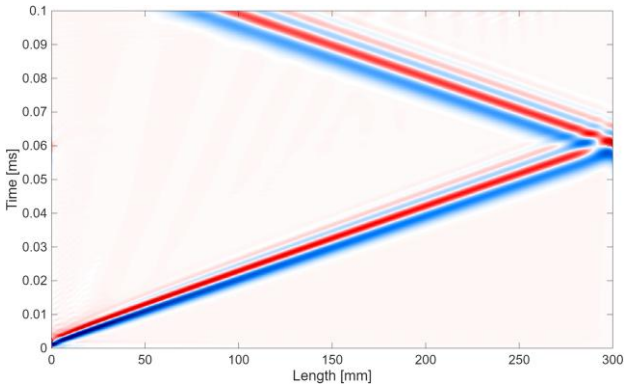
left-to-right particle displacement

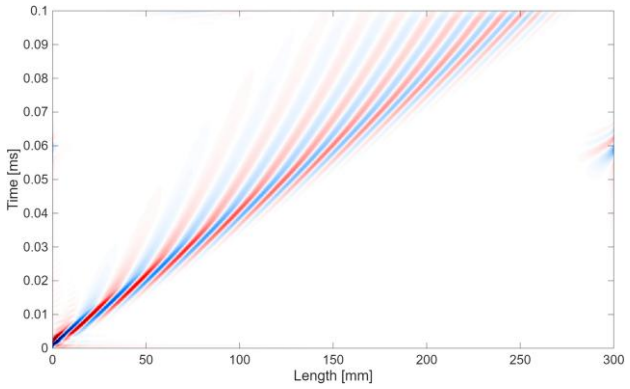


right-to-left particle displacement



8. Design a filter in the frequency domain that eliminates one of the wave modes (symmetric or antisymmetric), as shown below.





9. Calculate similar dispersion curves for particle displacement measured out-of-plane *(Displacement Y)*. What are the differences between *Displacement X* and *Displacement Y*? Name the appropriate wave modes.