Simulation of Laser-Excited Surface Acoustic Waves Traveling on a Hemispherical Steel Shell

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INTRODUCTION: Quantitative NDE of complex geometries is useful but nontrivial. Generation and propagation of laser excited Lamb waves was modeled on a hemispherical shell. Simulation predictions were compared to experimental data. A simulation to show defect detection capability was also carried out.

COMPUTATIONAL METHODS: To model laser excitation and wave propagation, the Solid Mechanics module was coupled to the Heat Transfer Module with Thermal Expansion multiphysics coupling. A 2D axisymmetric model for an intact hemispherical shell and a 3D model for a shell with a Ø=9.5 mm hole were simulated.

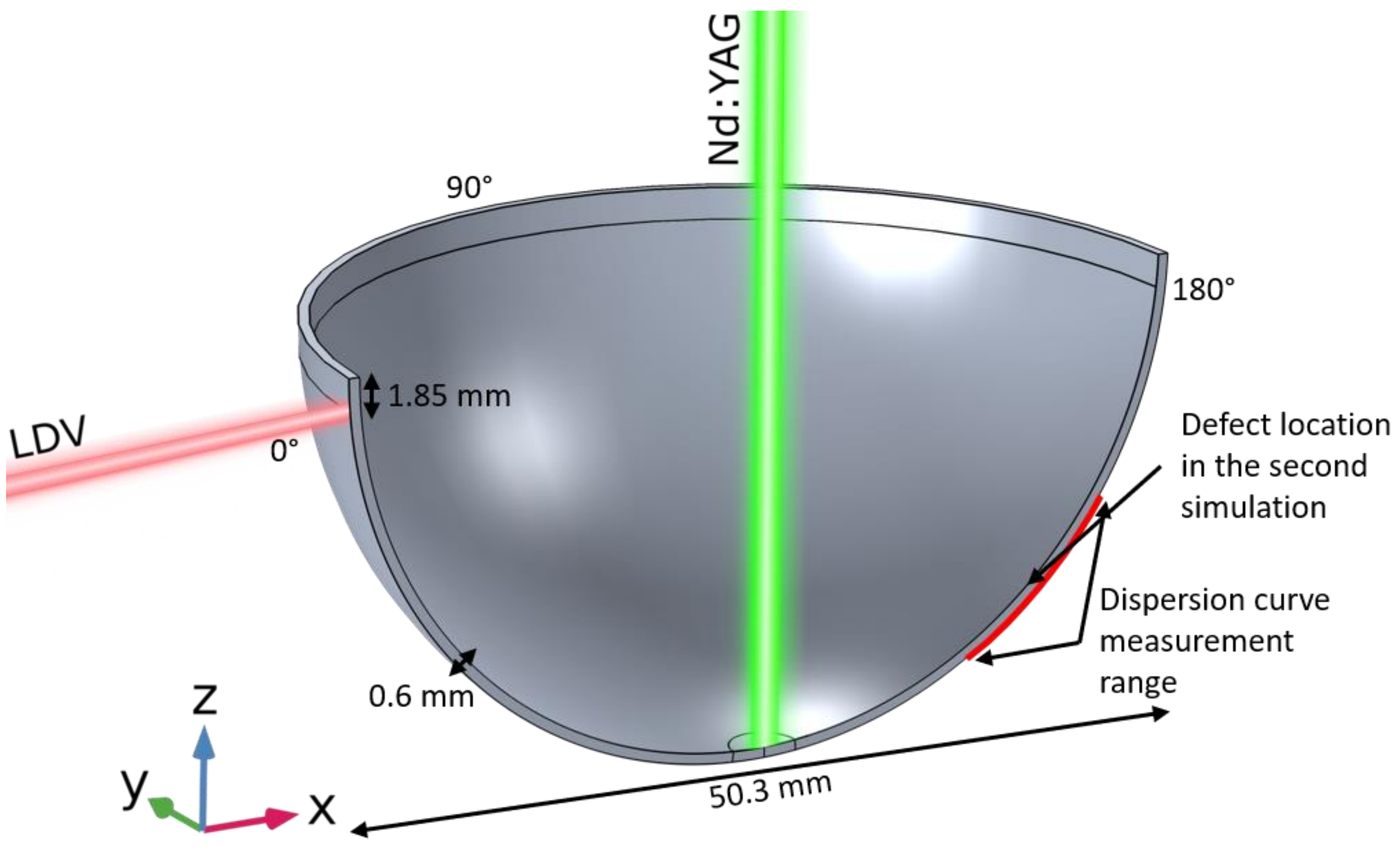

Figure 1: Schematic of an intact hemispherical shell being measured.

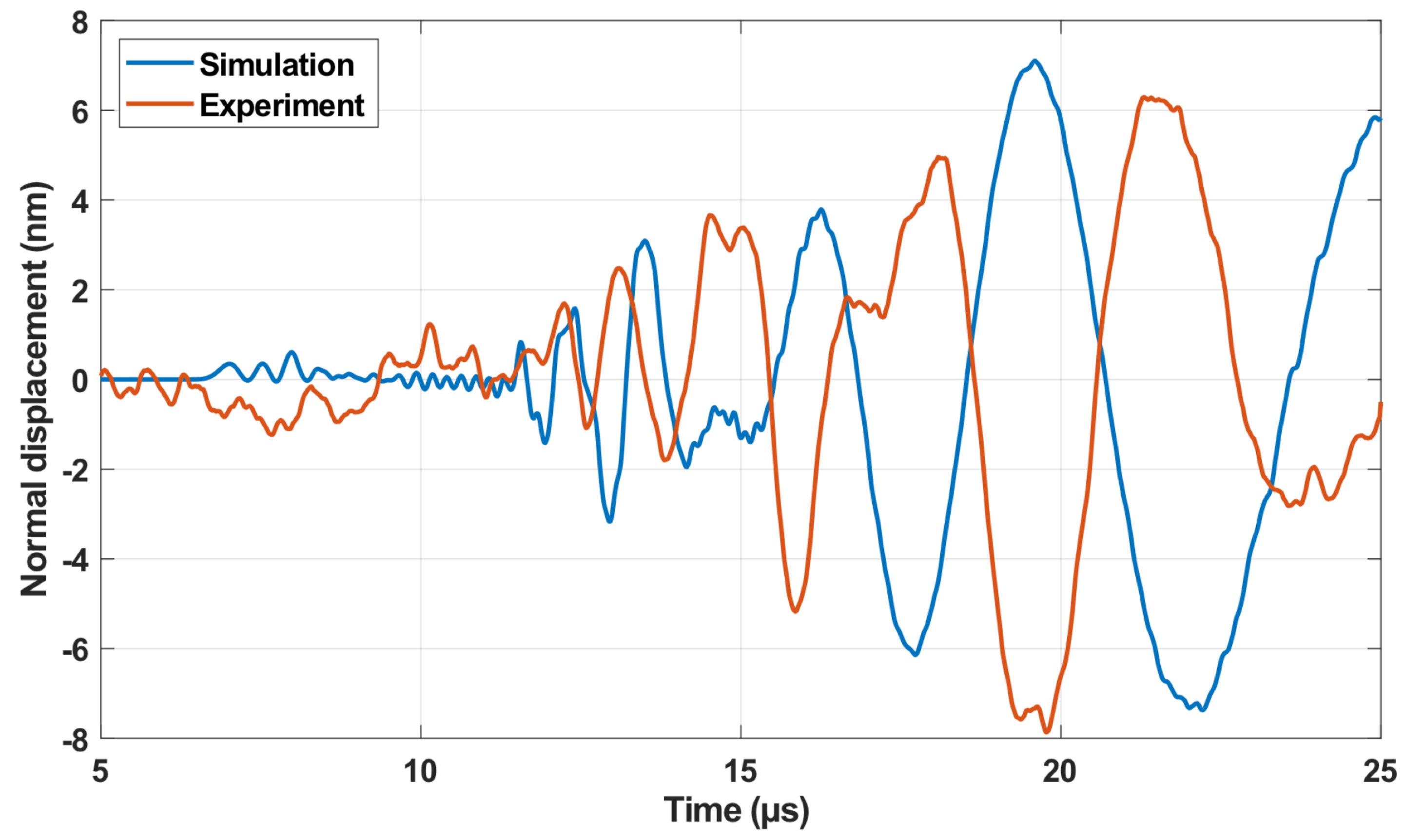

Figure 2: Simulated and measured displacement in a hemispherical shell.

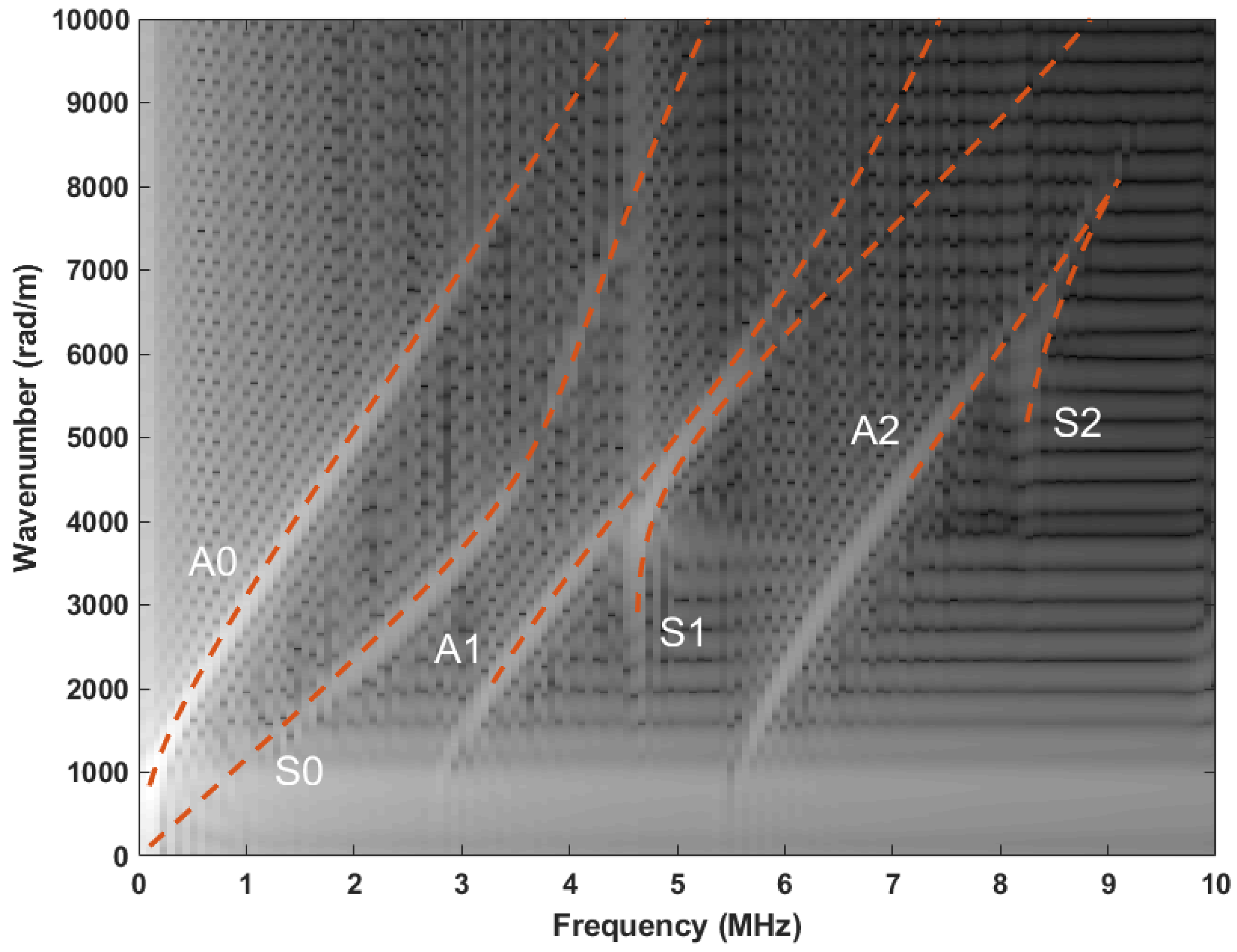

Figure 3: Lamb wave dispersion curves predicted by 2D axisymmetric simulation and theoretical predictions (orange lines).

RESULTS: Lamb wave propagation on an intact steel shell (2D axisymmetric model) is compared to measurements (Fig. 2) and theoretical values (Fig. 3). In Fig. 2 normal displacement is compared. Fig. 3 compares dispersion curves predicted by the simulation to theoretical values for a plate. In Fig. 4 the effect of a Ø=9.5mm defect is shown as a waterfall plot along the outer rim of the shell.

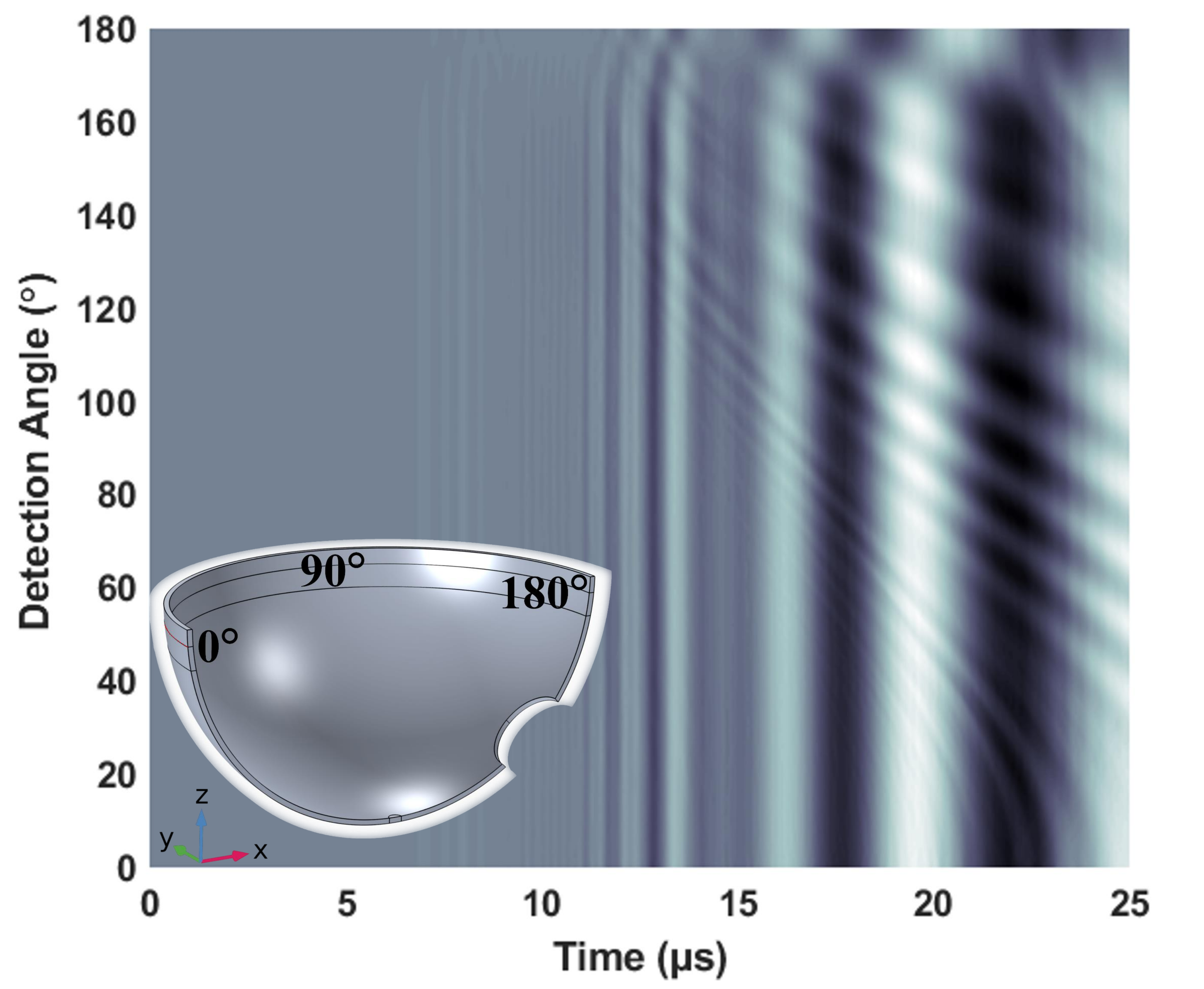

Figure 4: Waterfall plot of a simulation model featuring a defect.

CONCLUSIONS: COMSOL Multiphysics® can model thermoelastic structural interaction that produces Lamb waves on a hemispherical structure (laser ultrasonics). Measured results for a 0.6 mm thick hemispherical shell were compared to those predicted by simulations. The simulated data shows that a defect should be detectable experimentally.