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ABSTRACT:

The Beauty of Chladni Dynamics - Experimental Experiences and Computational Challenges

Ernst Florens Friedrich Chladni published his book on the theory of sound in 1787. In his experiments, he excited plates at their natural frequencies and made the natural modes visible by using sand, which moved to the zero contours of the natural modes, delighting observers with the beauty of these Chladni figures. Through this wonderful book and his scientific work during his lifetime, he was able to inspire people for more than two centuries with the science of continuum and structural dynamics. Driven by the desire to solve Chladni figures mathematically, Walter Ritz invented a calculation method based on variation principles and approximative solution in early 1908, which was further developed into the finite element method during the 20th century and is now the most important solution method in the natural sciences and engineering.

The lecture reflects on Chladni's scientific achievements and transports them into the modern context of research on dynamics.

Both experimental and modeling and simulation perspectives are presented.

In the field of experimental dynamics, methods of excitation and vibration measurement are presented and used to measure natural dynamics and transient behavior. It will be shown that even higher-accuracy finite element methods with Gaussian integration adapted for dynamics reach their limits when simulating Chladni figures. These limits are to be extended with alternative finite elements developed specifically for dynamics. Discontinuous and continuous Galerkin time integrators are used to simulate transient behavior and are examined comparatively. Based on the comparison of experiment and simulation, new insights into the nonlinear stiffening of plates clamped on both sides are expected.

In addition, this comparison can will be used to draw conclusions about the requirements for realistic modeling of damping in nonlinear structural dynamics.

Literature

Chladni E.F.F.: Entdeckungen über die Theorie des Klanges (Discoveries about the theory of sound). Leipzig, 1787.

Ritz, W.: Über eine neue Methode zur Lösung gewisser Variationsprobleme der mathematischen Physik (On a new method for solving certain variation problems in mathematical physics). Zeitschrift für angewandte Mathematik und Mechanik (Journal of Applied Mathematics and Mechanics), Vol. 135(1), 1-61, 1908.