Nonlinear Panel Flutter Phenomena in Transonic Flow

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The present work deals with nonlinear panel flutter phenomena in transonic flow. For this purpose, a high order accurate and efficient method for computational aeroelasticity has been developed. Aerodynamics are modeled using the inviscid, compressible Euler equations and nonlinear Timoshenko beam elements are employed for the structure. Time-discontinuous Galerkin least-squares finite elements are employed for both the transonic fluid flow [3] and the elastic aircraft wing structure [4]. Time dependent deformations of fluid domains are modeled using space-time mappings for the finite element geometry [5]. A least-squares term is applied to stabilize the convective term. In order to get sharp resolution of discontinuities without spurious oscillations, a consistent high order shock-capturing operator is added. The resulting implicit time marching scheme is unconditionally stable and 1st or 3rd order accurate.

Based on the discretization of equal type for fluids and structures, an overall iterative solver strategy for the fully coupled problem analogous to [1] has been developed. For this purpose, a modified Newton iteration of the fluid nonlinearity, a structure iterative solver and the fluid-structure coupling iteration are combined in one common loop. This leads to a significant reduction of the overall computer time without any convergence problems of the present scheme.

The algorithm is proofed by panel flutter computations for transonic Mach numbers. It is shown that nonlinear shock motions in fluid domain are the governing effect and may lead to limit cycle oscillations, see Fig.1. Comparison to results obtained by [2] shows very good agreement.

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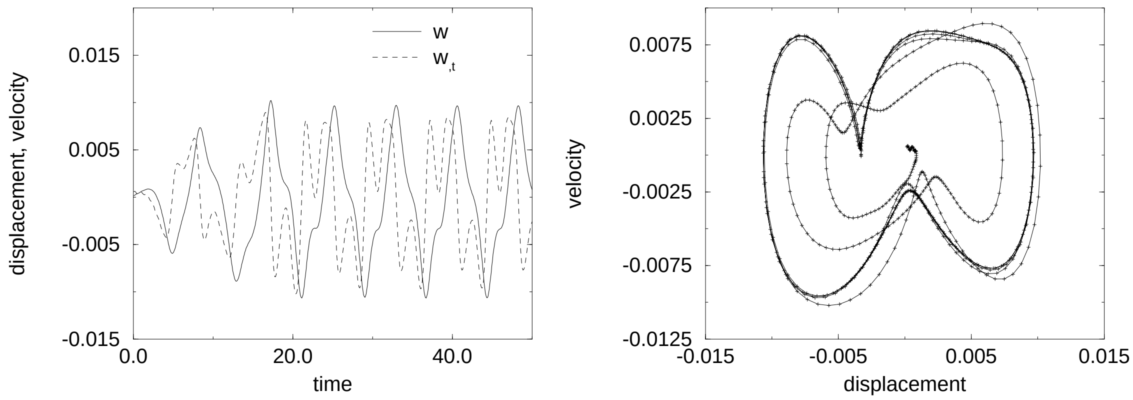

Figure 1: Transonic panel flutter at $M = 1.1$, $\lambda = 314$, $\mu = 0.1$ and $h/t = 0$: time history (left) and phase diagram (right) of deformation $w(t)$ and velocity $w_{,t}(t)$ at $x/l = 0.75$.

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