Fast reduction of nonlinear finite-element models to spectral submanifolds

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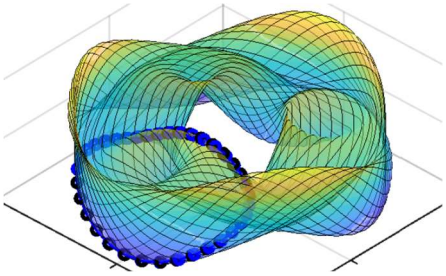
Despite advances in computational power, computing the forced response of large, nonlinear mechanical systems for different forcing frequencies has remained a major challenge. Indeed, direct numerical integration converges slowly in the presence of small damping, while numerical continuation and harmonic balance algorithms become quickly unfeasible for high-dimensional systems. Projection-based model reduction techniques have been in use but tend to rely on ad hoc mode selection and produce a priori unknown errors. A recent alternative to these approaches is provided by the theory spectral submanifold theory, which enables a mathematically exact reduction of a very high dimensional nonlinear oscillatory systems to very low dimensional invariant manifolds. With the help of this reduction, previously unimaginable computational speeds can be achieved in computing nonlinear forced response, including detached branches (isolas) and quasiperiodic response near internal resonances. We discuss and illustrate these recent developments on examples ranging from high-dimensional oscillator systems to nonlinear finite element models of beams and shells. We will also briefly introduce an open-source numerical package that performs such computations for general nonlinear vibration problems.



Bio-sketch of George Haller

George Haller received his Ph.D. in Applied Mechanics at Caltech in 1993. He then held tenured faculty positions at Brown University, MIT and McGill University.
He currently holds the Chair in Nonlinear Dynamics at ETH Zürich. His honors include an Alfred P. Sloan Research Fellowship in mathematics, an Albert Szent-Gyorgyi Fellowship, an ASME Thomas J.R. Hughes Young Investigator Award, and an Honorary Doctorate from the Budapest University of Technology and Economics. He is an elected external member of the Hungarian Academy of Sciences, an elected Fellow of th American Physical Society (APS) and an elected Fellow of the Society of Industrial and Applied Mathematics (SIAM). His research is focused on nonlinear dynamical systems with applications to mechanical vibrations, model reduction and coherent structures in turbulence.