Ekici, Kivanc; Djeddi, Reza; Li, Hang; Frankel, Jay I.
Modeling periodic and non-periodic response of dynamical systems using an efficient Chebyshev-based time-spectral approach. (English) Zbl 1437.76038

Summary: A Chebyshev-based time-spectral method (C-TSM) is developed to model periodic and non-periodic nonlinear dynamical systems. It is shown that the proposed technique can accurately model such problems eliminating the need to use expensive classical dual-timestepping time-accurate integration. Furthermore, for autonomous dynamical systems subjected to single or multiple fundamental frequencies, the C-TSM analysis can be used without the prior knowledge of those frequencies. This offers an apparent advantage over the Fourier-based time-spectral methods. In addition, the current approach lends itself as a very useful tool for transient adjoint-based sensitivity analysis since it greatly reduces the memory requirements by solving and storing time-dependent response at a handful of collocation points instead of storing the entire time-history of the primal solution. The efficacy of the present technique is demonstrated by directly comparing the results with Fourier-based time-spectral, as well as time-accurate methods.

MSC:
76M22 Spectral methods applied to problems in fluid mechanics
76N06 Compressible Navier-Stokes equations
76D17 Viscous vortex flows
34C15 Nonlinear oscillations and coupled oscillators for ordinary differential equations
34C60 Qualitative investigation and simulation of ordinary differential equation models

Keywords:
unsteady flow; Chebyshev series; time-spectral method; harmonic balance; aperiodic flow; nonlinear dynamics

Software:
Spalart-Allmaras; SU2

Full Text: DOI

References:

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