6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

Analysis of Fluid-Structures Interaction using a Harmonic Balance solver

W. Yao[1], S. Marques[2]

[1] School of Mechanical and Aerospace Engineering, Queen's University Belfast, Belfast, UK, BT9 5AH, w.yao@qub.ac.uk
[2] Department of Mechanical Sciences, University of Surrey, Guildford, UK, GU2 7XH; s.marques@surrey.ac.uk

Keywords: *Fluid-Structures Interaction, CFD, Aeroelastics, Nonlinear, Harmonic-Balance*

For elastic structures subject to fluid flows, the fluid-structure interaction can lead to unstable behaviours such as flutter. However, if flow or structural nonlinearities are present, the amplitude of oscillations can become bound, resulting in a periodic orbit or limit cycle. The Harmonic-Balance (HB) technique is a viable alternative to direct time integration methods for such problems. The HB method transfers the time dependent problem into a steady solution based on Fourier expansions, which can be more or less straightforward if the frequency of the oscillations is known *a priori*[1].

This work presents an Aeroelastic-Harmonic-Balance formulation using a frequency updating procedure. In particular, we focus on an approximate exponential time-integrator that accelerates the convergence of the structural equations of motion to the final solution. We also extend this methodology to problems including structural and flow nonlinearities. Initial results for transonic limit cycle oscillations are shown in Figure 1; speed-ups of two orders of magnitude with respect to conventional methods are observed. The final paper will feature more challenging cases, including the analysis of vortex-induced vibration frequency lock-in and further transonic LCOs; the performance of the algorithm will be further reviewed and ananlysed.

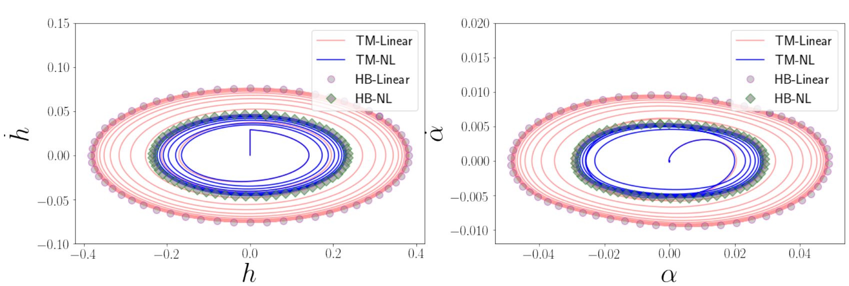

Figure 1: Position-velocity diagram for an aerofoil LCO at $M_\infty = 0.8$ with linear and nonlinear structure

REFERENCES

[1] W. Yao and S. Marques, Prediction of transonic limit-cycle oscillations using an aeroelastic harmonic balance method. *AIAA J.*, Vol. **53**(7), pp. 2040–2051, 2015.