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Automatic-differentiated shadowing methods for optimization and data assimilation of chaotic acoustics NISHA CHANDRAMOORTHY, Massachusetts Institute of Technology MIT, LUCA MAGRI, University of Cambridge, QIQI WANG, Massachusetts Institute of Technology MIT — In an acoustic cavity with a heat source, a feedback loop between the pressure waves and the heat released by a source can, under resonant conditions, result in loud oscillations. These undesirable nonlinear oscillations, known as thermoacoustic instabilities, can be chaotic. While effective sensitivity-analysis-based control of instabilities is well-established for eigenvalues, control of chaotic oscillations presents a unique challenge due to the extreme sensitivity of chaotic systems (the butterfly effect). We present a computational analysis and applications to tackle the optimization and data assimilation of the chaotic thermoacoustic oscillations. In particular, we illustrate i) sensitivity analysis ii) parameter optimization and iii) data assimilation, on a chaotic thermoacoustic model. We present a discrete shadowing algorithm, based on unifying the tangent and adjoint versions of the Non-Intrusive Least Squares Shadowing algorithm. We compute the sensitivity of the ergodic averages of the acoustic energy and the Rayleigh index, and use the computed sensitivities for optimizing the heat release rate. Finally, we also develop a shadowing-based algorithm for data assimilation, which improves the predictability of hyperbolic chaos, possibly with a constant time delay.

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