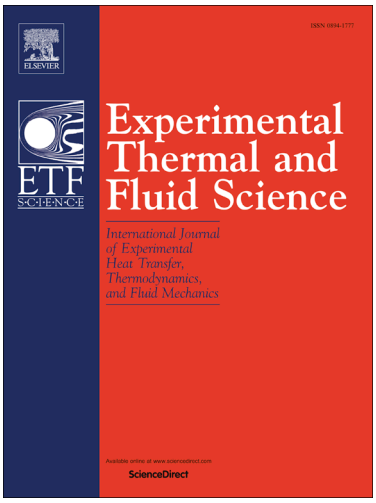


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# Nonlinear time-series analysis of thermoacoustic oscillations in a solid rocket motor

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**Abstract**

Recent applications of nonlinear time-series analysis have shown that thermoacoustic systems can exhibit self-excited behavior more complex than simple period-1 oscillations. Such behavior has been comprehensively explored in the Rijke tube and in gas turbines, but less so in rocket engines. In this experimental study, we examine the thermoacoustic oscillations of a full-scale solid rocket motor (SRM) by means of nonlinear time-series analysis, namely phase portraits, Poincaré maps and recurrence plots. In contrast to conventional linear tools based on the Fourier transform, these nonlinear tools can enable unambiguous identification of different dynamical states, such as period-$k$ states, quasiperiodicity and chaos. In this study, these tools reveal limit-cycle dynamics not reported before in an SRM, such as transient mode switching between unstable attractors in phase space, with transitions between period-2 and period-3 states. In summary, this study constitutes the first experimental application of nonlinear time-series analysis to a full-scale SRM, demonstrating an alternative to conventional linear tools for the characterization of nonlinear thermoacoustic oscillations in rocket engines.

*Keywords:* thermoacoustics, combustion instability, nonlinear dynamics, rocket engines

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