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Least-order parametric modeling of an incompressible open cavity flow

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Abstract

We propose a least-order model capable of reproducing the transient and asymptotic dynamics of an incompressible open cavity flow for interpolated and extrapolated values of the Reynolds number, over the range $Re \in [4140, 4340]$. The approach is based on projecting the dynamics of the complete system, for different values of the Reynolds number, onto an empirical basis of "bifurcation modes", as introduced by [1].

As the flow instability results from a supercritical Hopf bifurcation, the least-order model is based on only three basic modes. The resulting model then takes the following form, for each of the system's three degrees of freedom a), $a_2(t)$, $a_3(t)$ [1], [2]:

where is slaved to),), when and].

The coefficients of the least-order model are physically identified from the transient and asymptotic dynamics of the system, and then the SINDy algorithm is used for sparse identification of the remaining coefficients [3]. We demonstrate the effectiveness of the interpolated model in reproducing the dynamics of the real system, and evaluate the model's performance for extrapolated values of the Reynolds number.

Keywords

Reduced-order modeling, supercritical Hopf bifurcation, parametric model, Galerkin decomposition, POD

References

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