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TIME–DEPENDENT DYNAMICS OF RAYLEIGH-BÉNARD CONVECTION INSIDE A CUBICAL CAVITY

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The identification of invariant objects and the study of the stability characteristics and bifurcations associated to these objects, and the knowledge of their invariant manifolds in case of hyperbolicity are crucial issues to understand the dynamics of complex systems. In particular, the detailed analysis of complex bifurcation scenarios in fluid mechanics problems provides relevant information on the mechanisms of generation and evolution of chaotic dynamics. In the current work time–dependent dynamics of the Rayleigh-Bénard convection inside a cubical cavity with perfectly conducting lateral walls was numerically investigated for moderate values of the Rayleigh number ($Ra \leq 1.5 \times 10^5$) and two Prandtl numbers, namely $Pr = 0.71$ and 130.

A Galerkin spectral method was used for the spatial discretization of the momentum and energy conservation equations. The dimension of the resulting ODE system was $N \approx 11000$. The bifurcation diagrams previously calculated for steady solutions [1] and periodic orbits [2] were extended. Four periodic solutions and five quasi–periodic solutions were identified to be stable at $Pr = 130$. Global bifurcations such as saddle–node on an invariant circle (SNIC) and gluing bifurcations turned out to be relevant in the transitions between different branches of time–dependent solutions. A route from quasi–periodic to chaotic dynamics was found at $Pr = 0.71$. Several interesting phenomena such as phase–locking and a sequence of period–doublings followed by a sequence of period–halvings were identified in this route.

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