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Square cavity flow driven by two mutually facing sliding walls

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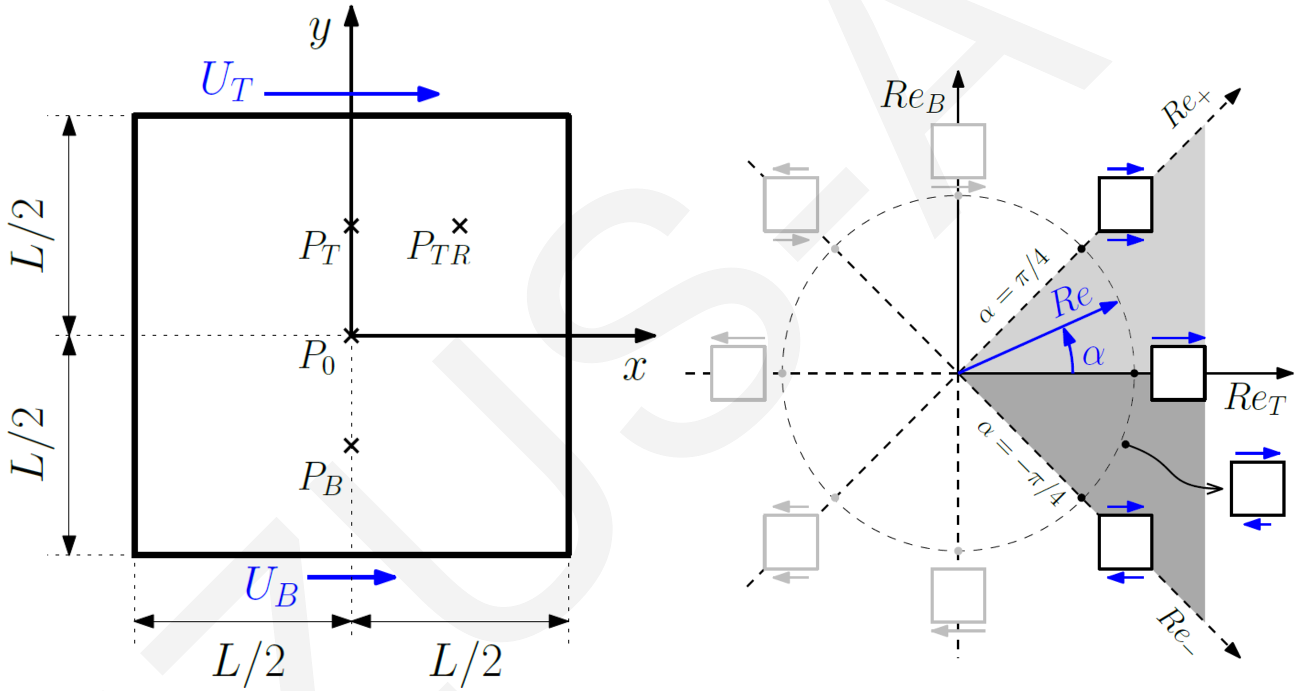
Problem stated



(a) ***(b)***

Fig. 1. Two-facing-walls-driven square flow, *S2a*. *(a)* Domain. *(b)* Parameter space

Flow Bifurcations for different values of velocity ratio

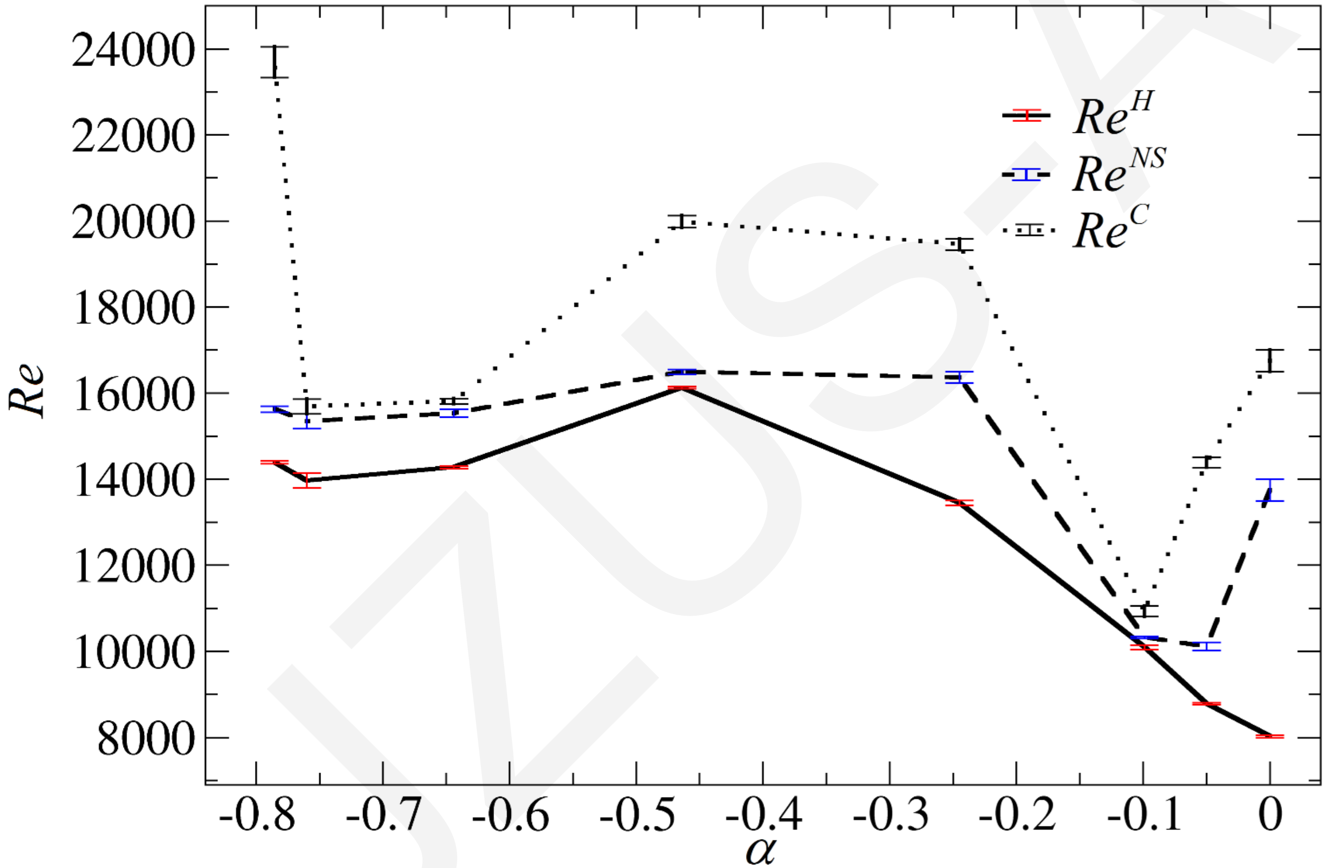
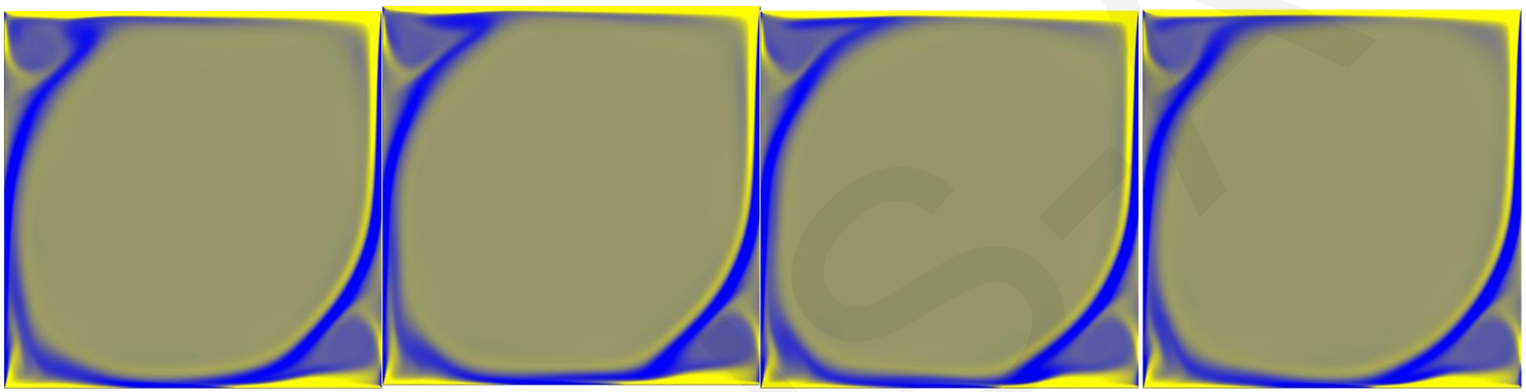


Fig. 2. Hopf bifurcation, Neimark-Sacker bifurcation and Choas-triggering bifurcation in $Re - \alpha$ parameter space

Flow topology of periodicity



$t_0 = 0$ $t_1 = T/4$ $t_2 = T/2$ $t_3 = 3T/4$

$Re = 14431, \alpha = -0.2499$

Fig. 3. Flow topology at different time steps within a full period *T*.

Chaotic Characteristics

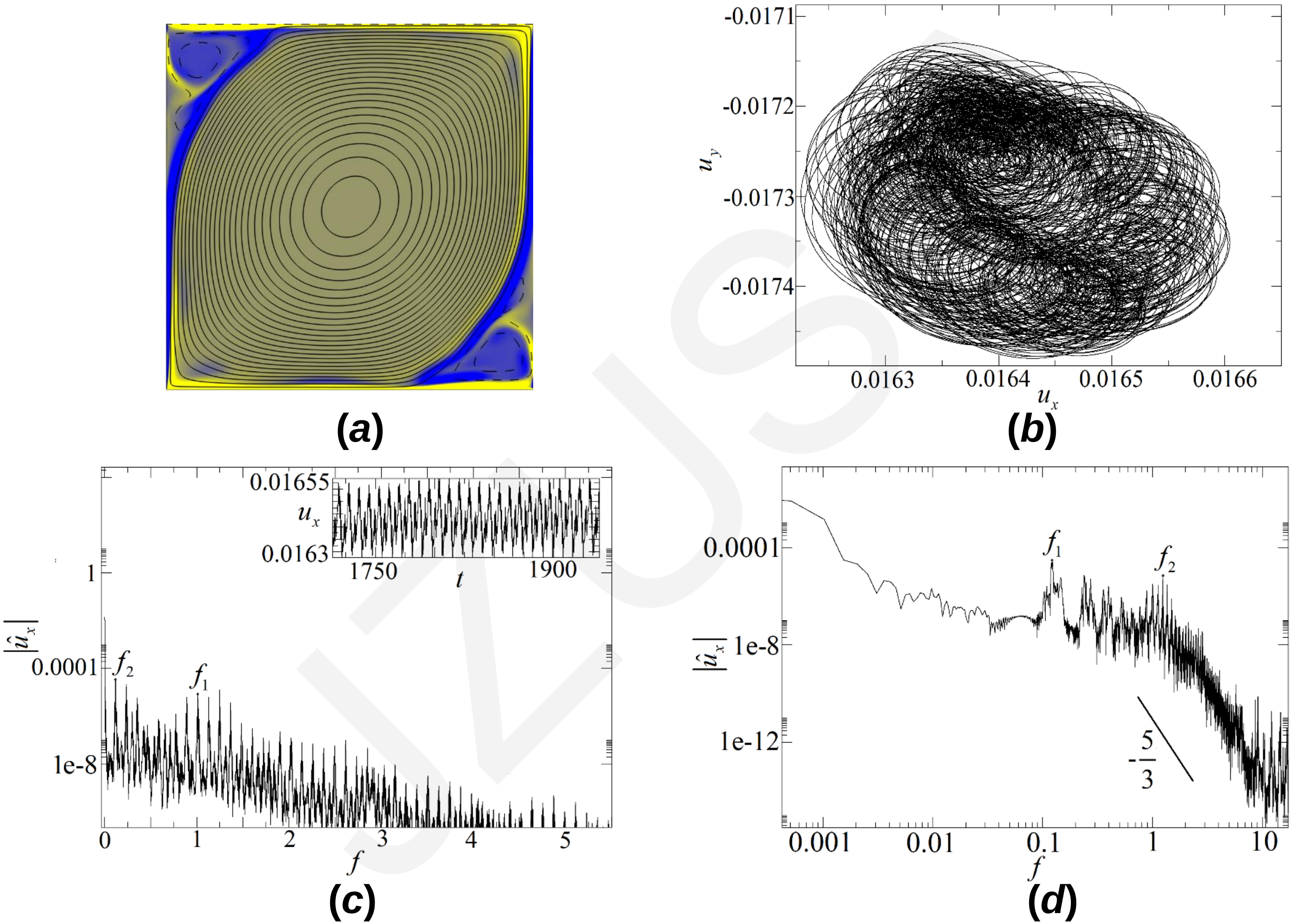
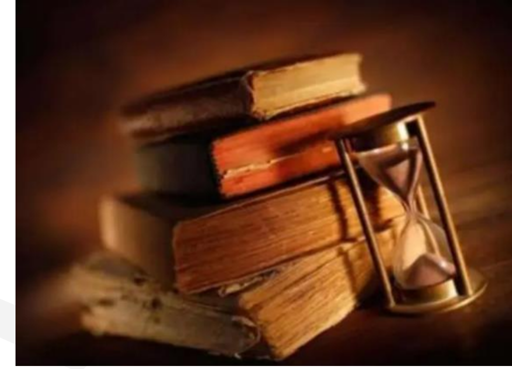


Fig. 4. (*a*) Flow topology. (*b*) Phase map. (*c*) Spectrum of velocity. (*d*) Spectral decomposition

Conclusions



We have found, as expected, that the first instability is always a Hopf bifurcation, such that the flow becomes periodic. The classic lid-driven cavity is the one that destabilizes earliest, the motion of the second lid having a stabilizing effect. The stabilization is maximal for $\alpha = -0.464$, with smaller (negative) values tending to reduce the critical value Re^{H}. The case $\alpha = -\pi/4$, however, is a relative maximum for Re^{H}, meaning that the disymmetrisation from equal speeds has locally a slightly stabilizing effect.

The destabilization of the periodic solution occurs, for the values of the parameters prescribed here, always through a Neimark-Sacker bifurcation. The trend of the critical curve is however different from that corresponding to the Hopf bifurcation. Setting the second lid in motion has a highly destabilizing effect for the periodic solution. Therefore, the periodic solutions are confined to a very narrow range of Re for $\alpha = -0.1$. A similar effect takes place for $\alpha = -0.464$ despite periodic solutions being stabilized, on account of the steady solution being strongly stabilized (see figure 9).

Quasi-periodic solutions seem to break into chaotic dynamics for all alpha explored. For $\alpha = -0.1$ and close to $-\pi/4$, quasi-periodicity subsists within a rather narrow range of Reynolds numbers. At exactly $-\pi/4$, however, the quasiperiodic solution is strongly stabilized. It seems that the pi-rotational symmetry has the effect of delaying chaos to a large extent.