Supplemental Materials

for the Dissertation Titled

Parametric Forcing of Confined and Stratified Flows

by

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movie-fig503

Animation of the vorticity η of three limit cycle states corresponding to figure 5.3 over one response period (two forcing periods). The three limit cycles are $\mathrm{L}_{1:2}$ at forcing frequency $\omega = 0.91$ with forcing amplitude $\alpha = 0.16$, $\mathrm{L}_{1:1}$ at $\omega = 1.41$ with $\alpha = 0.07$, and $\mathrm{L}_{2:1}$ at $\omega = 1.81$ with $\alpha = 0.06$.

movie-fig514

Animation corresponding to figure 5.14, illustrating how the local and global strobe maps of the flow at forcing frequency $\omega = 1.35$ vary with forcing amplitude α. Demonstrates the homoclinic doubling cascade as α is decreased.

movie-fig515

Animation of the isotherms T (first row) and vorticity η (second row) of the four indicated limit cycles over two forcing periods at forcing frequency $\omega = 1.41$. The limit cycles shown are $\mathrm{L}_{1:1}$ at forcing amplitude $\alpha = 0.07$ (first column), L_L at $\alpha = 0.105$ (second column), L_R at $\alpha = 0.105$ (third column), and $\mathrm{L}_{2:2}$ at $\alpha = 0.105$ (fourth column). Corresponds to figure 5.15.

movie-fig516

Animation of the isotherms T (left column) and vorticity η (right column) for the S_2 state at $(\omega, \alpha) = (1.41, 0.111)$ over six forcing periods. Obtained by restricting the direct numerical simulation to the $\mathcal{K}_z$ symmetry subspace. Corresponds to figure 5.16.

movie-fig518

Animation summarizing the dynamics observed in the $\mathcal{R}_\pi$ symmetry subspace as an indicated forcing amplitude α is increased by 0.01 for fixed forcing frequency $\omega = 1.41$, with the variance of a horizontal velocity at a point Σ (first row, first column), the number of forcing periods ω/ω_R associated with the slow response of the 2-tori states (second row, first column), and the associated strobe map sampling a horizontal velocity at a point u_p and a global measure of the temperature E_T every two forcing periods at forcing phase π (second column). Corresponds to figure 5.18.

movie-fig520

Animation of the strobe maps of a horizontal velocity at a point with a global measure of the temperature (u_p, E_T) and strobed vorticity η of Q_L, Q_R, and Q at fixed forcing frequency $\omega = 1.41$ and indicated forcing amplitude α near the first gluing. Q_L and Q_R are shown at $\alpha = 0.125$, and Q is shown at $\alpha = 0.126$. The strobe is taken every two forcing periods at forcing phase π. Corresponds to figure 5.20.

movie-fig522

Animation of the strobe maps of a horizontal velocity at a point with a global measure of the temperature (u_p, E_T) and strobed vorticity η of Q, Q_L, and Q_R at fixed forcing frequency $\omega = 1.41$ and indicated forcing amplitude α near the second gluing. Q is shown at $\alpha = 0.135$, while Q_L and Q_R are shown at $\alpha = 0.136$. The strobe is taken every two forcing periods at forcing phase π. Corresponds to figure 5.22.

movie-fig524

Animation of the strobe maps of a horizontal velocity at a point with a global measure of the temperature (u_p, E_T) and strobed vorticity η of Q_L, Q_R, and Q_B at fixed forcing frequency $\omega = 1.41$ and indicated forcing amplitude α near the third gluing. Q_L and Q_R are shown at $\alpha = 0.146$, and Q_B is shown at $\alpha = 0.147$. The strobe is taken every two forcing periods at forcing phase π. Corresponds to figure 5.24.

movie-fig526

Animation summarizing the upper-branch dynamics observed in the full space as an indicated forcing amplitude α is increased by 0.01 for fixed forcing frequency $\omega = 1.41$, with the variance of a horizontal velocity at a point Σ_u (first row, first column), the number of forcing periods ω/ω_R associated with the slow response of the 2-tori and 3-tori states (second row, first column), and the associated strobe map sampling a horizontal velocity at a point u_p and a global measure of the temperature E_T every two forcing periods at forcing phase π (second column). Corresponds to figure 5.26.

movie-fig527

Animation comparing strobed full space dynamics of Q_R (left column) and T_{3R} (right column) at forcing frequency $\omega = 1.41$ and forcing amplitude $\alpha = 0.138$ with a two forcing period strobe map of a horizontal velocity at point and a global measure of the temperature (u_p, E_T) at forcing phase π (first row) and the strobed vorticity η (second row). Corresponds to figure 5.27.