Periodic structures in 3D mixing flows


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Introduction

The laminar mixing process can be improved by introducing chaos in the flow. Time-periodic flows produce chaotic trajectories and the chaos is determined by periodic points. Figure 1 represents the flow geometry and the front and back wall induce the time-periodic motion.

Objectives

- study chaotic mixing using periodic point analysis
- develop numerical tools to analyze mixing

Chaotic Mixing

Chaos in the flow is determined by the periodic points. Periodic points return to their original position after one period $T$ and are classified into two groups:

- elliptic: center of non-mixing regions (islands)
- hyperbolic: center of stretching and folding

Numerical Techniques

- Time discretization: Pressure correction method
- Space discretization: Spectral element method

Mixing Analysis

In symmetrical flows, periodic lines cross the plane of symmetry $x = 0$ at the times $t_1 = T/4$ and $t_2 = 3T/4$. This plane is tracked from $t_1$ and $t_2$.

Conclusions

Periodic structures, which consist of lines, are found and classified in 3D cavity flows.