

Wash and Fold Group Meeting

Experimental Kolmogorov-Like Flow: Bifurcations, Boundary Conditions, and Recurrence Searches

Jeff Tithof

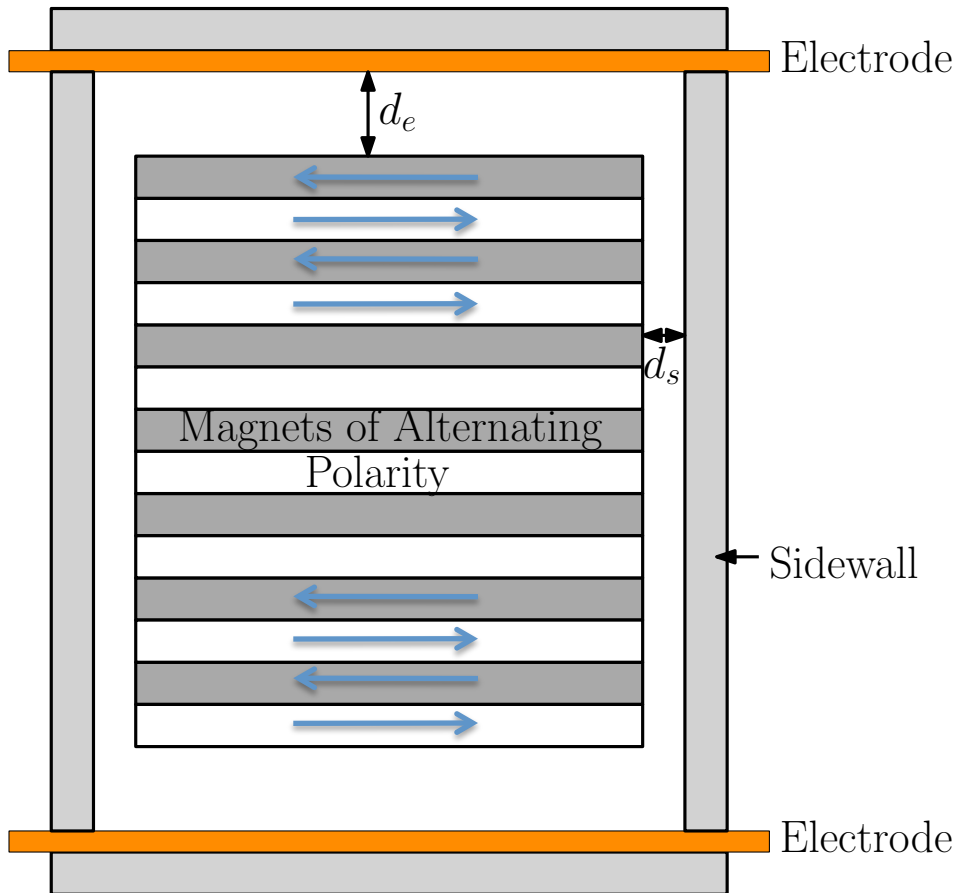
Sept. 9, 2013

Preview

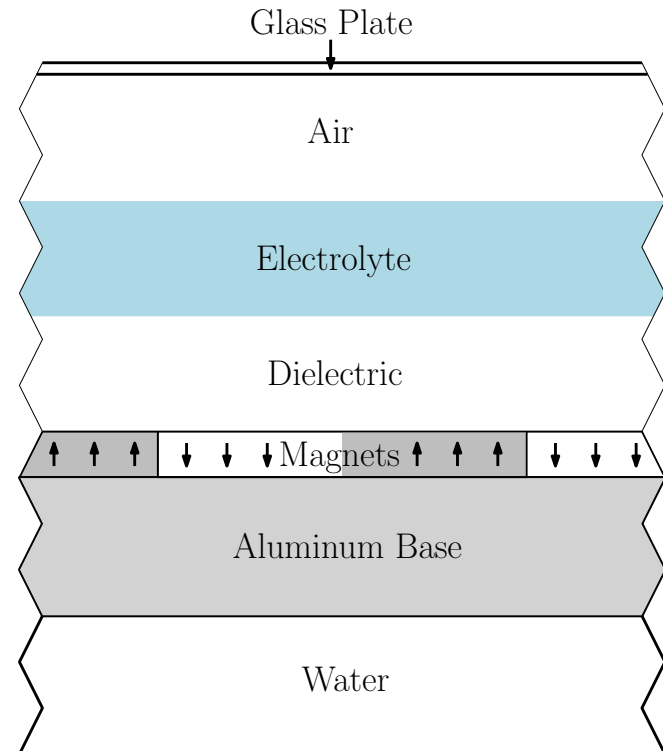
- Experimental Setup
- Bifurcations (Original Geometry)
- Effects of Different Boundary Conditions
- New Geometry
- Recurrence Analyses

Experimental Setup

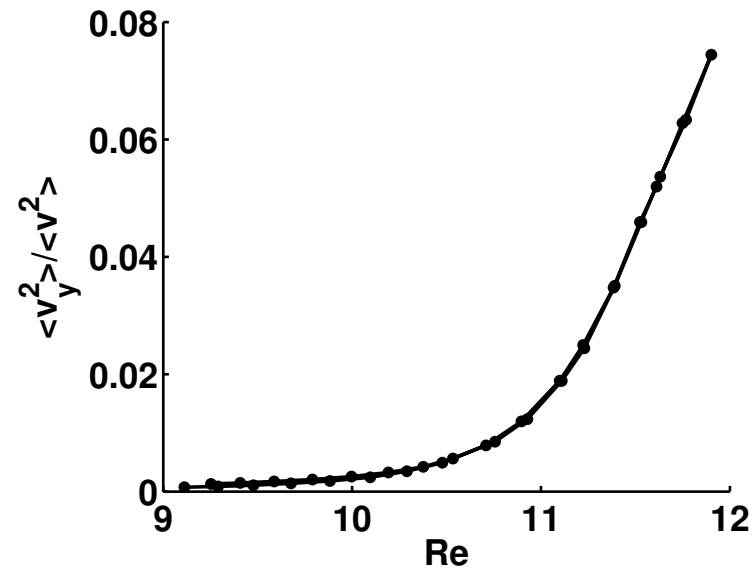
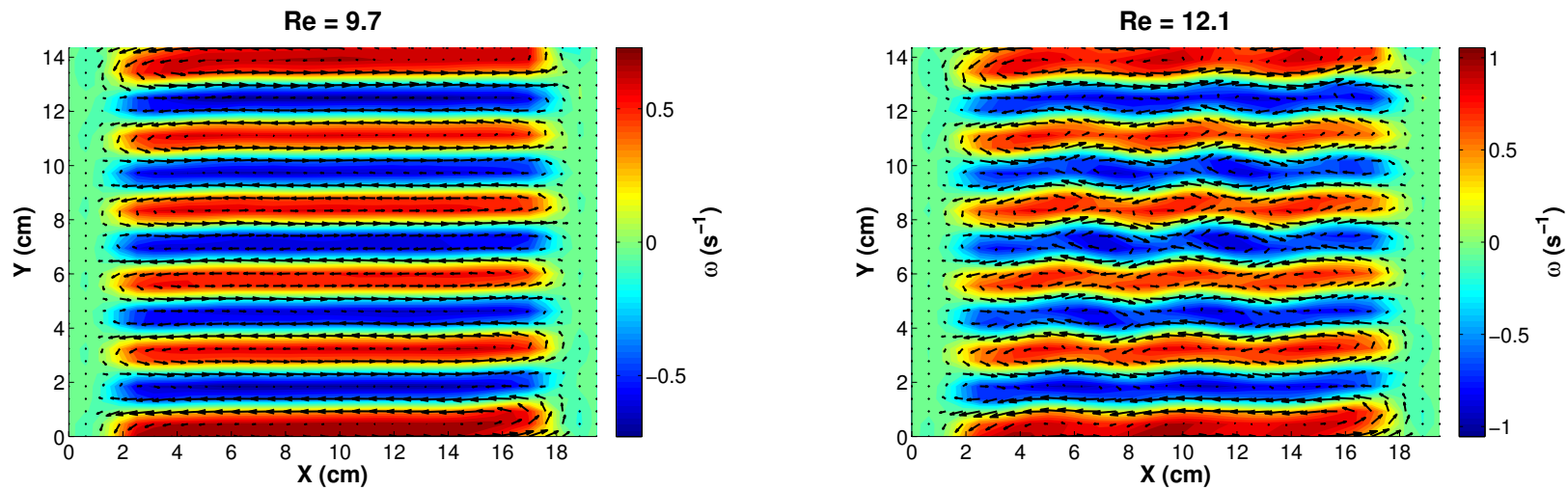
View From Above



View From Side

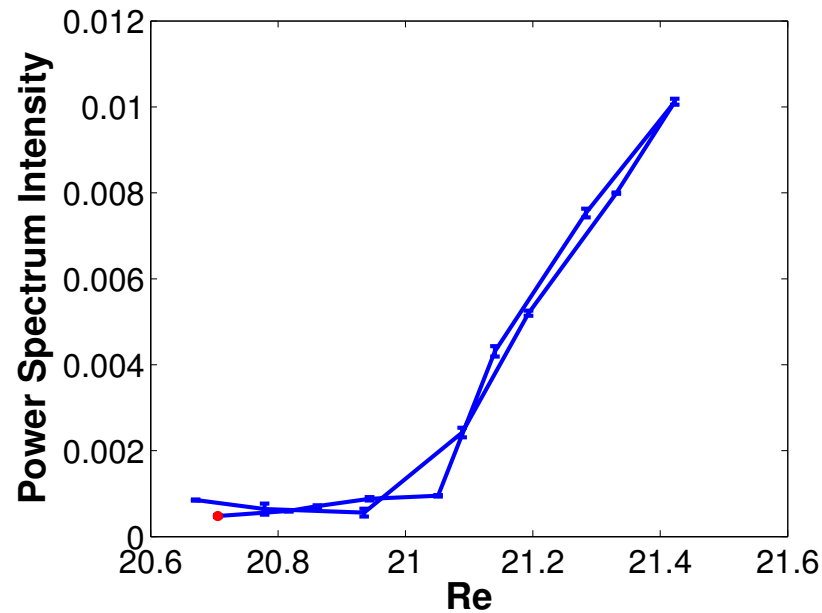
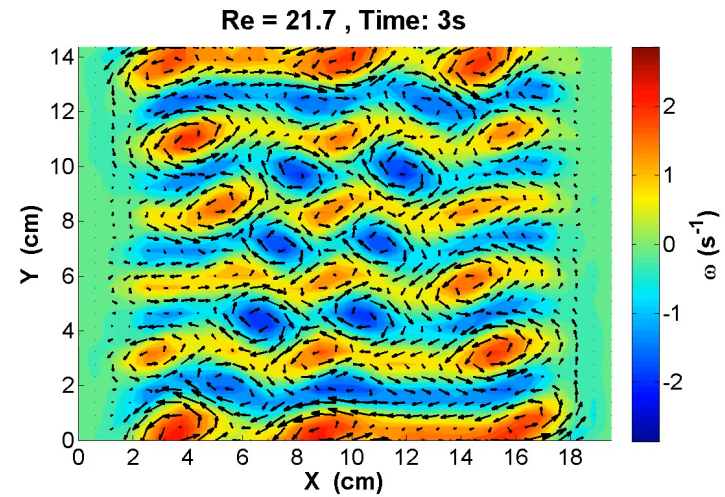
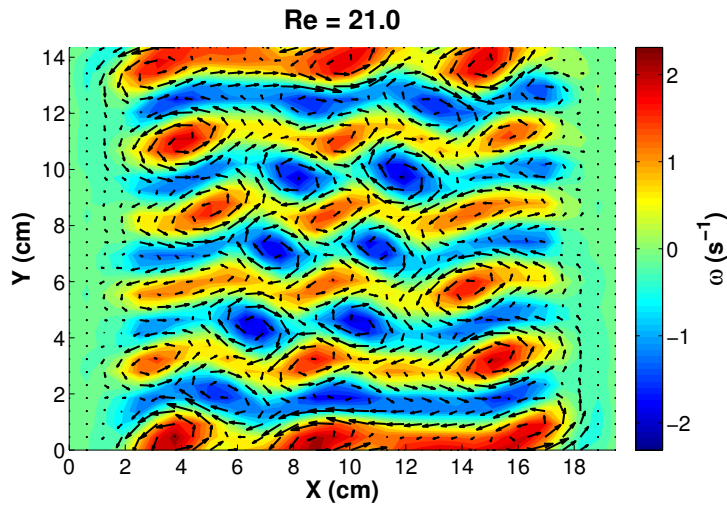


1st Bifurcation



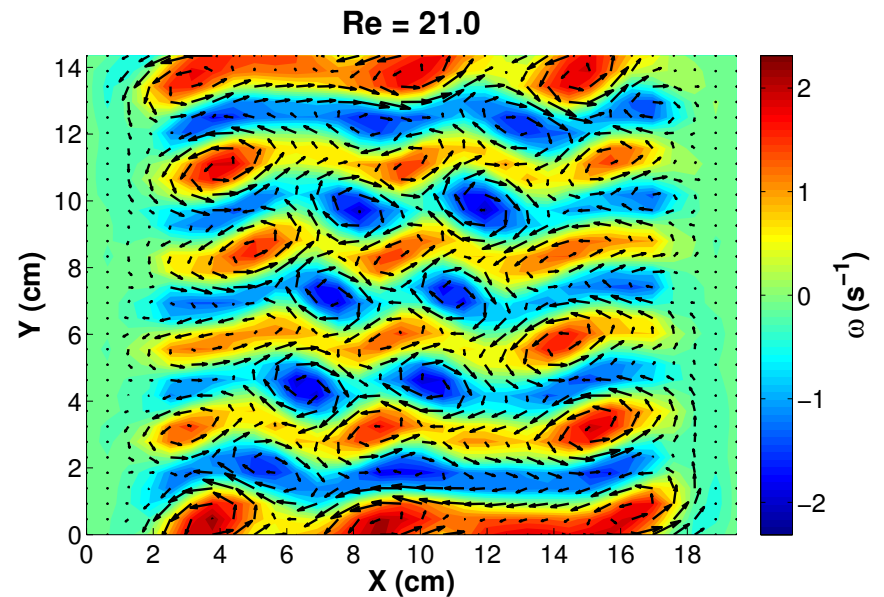
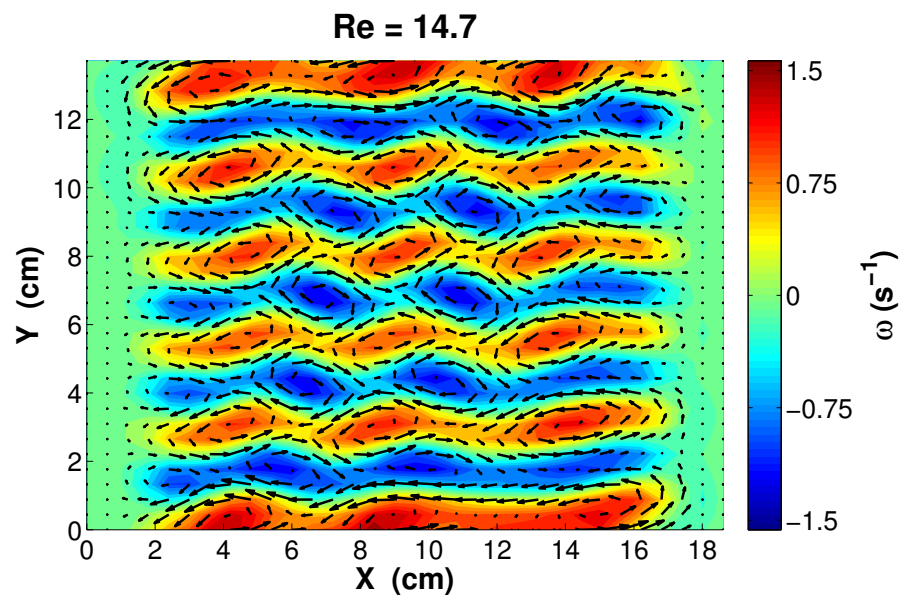
12 Magnet Setup
with $d_e = 0.3$ cm
and $d_s = 2.0$ cm

2nd Bifurcation



12 Magnet Setup
with $d_e=0.3$ cm
and $d_s=2.0$ cm

“Lattice Distortion”

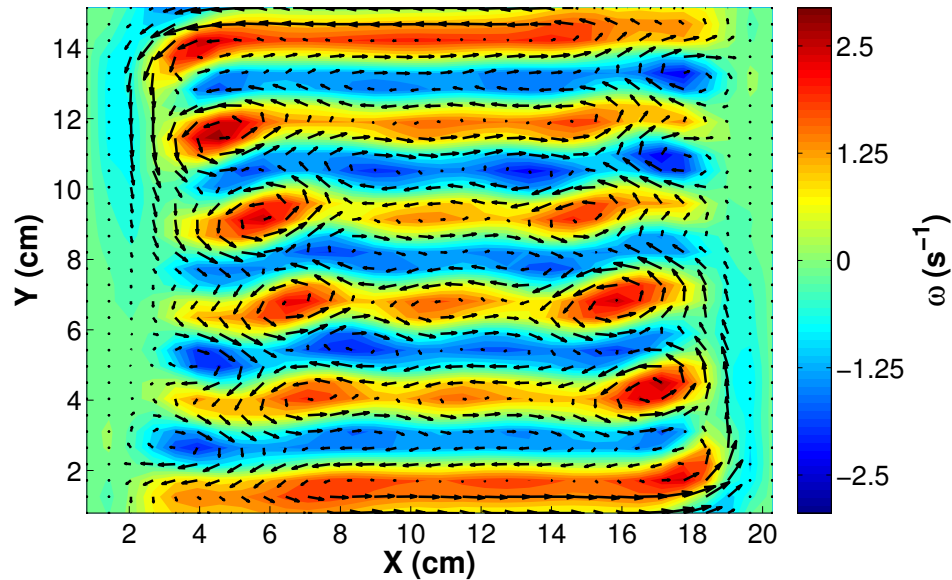


12 Magnet Setup
with $d_e=0.3$ cm
and $d_s=2.0$ cm

Time-Averaged Flow

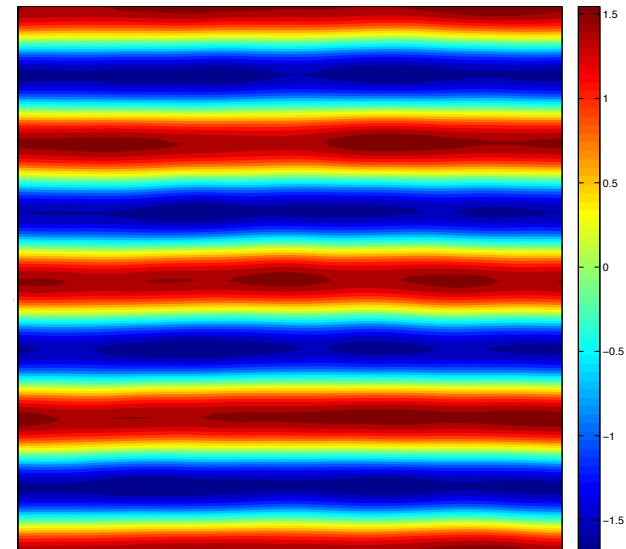
Experiment: Original Geometry
Averaged Over 1800s

$Re \approx 50$



Doubly-Periodic Simulation
Averaged Over 7200s

$Re \sim 53$

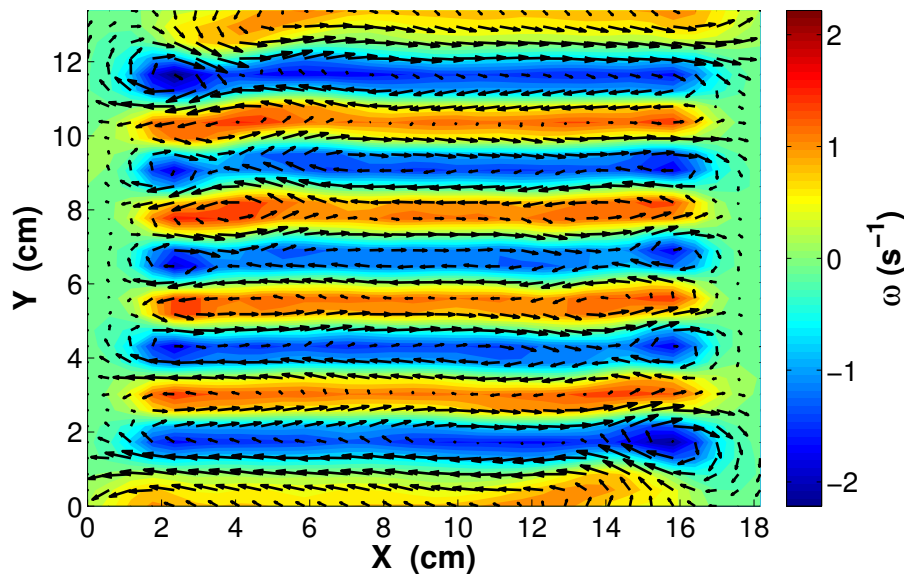


12 Magnet Setup
with $d_e = 0.3$ cm
and $d_s = 2.0$ cm

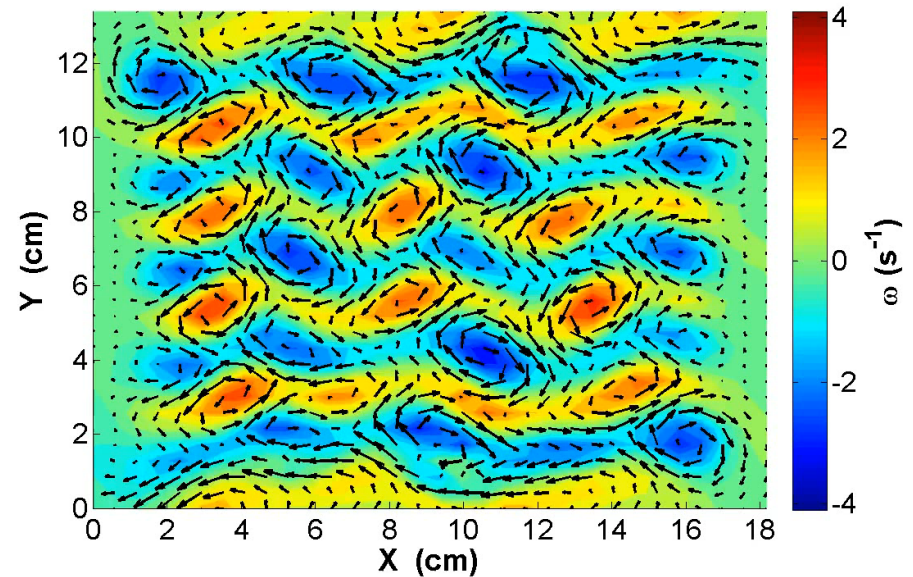
Effects of Varying the BC's (Far Electrodes and Far Sidewalls)

Time-Averaged Flow Field (30 min)

Re = 28.1



Re = 28.1 , Time: 2s

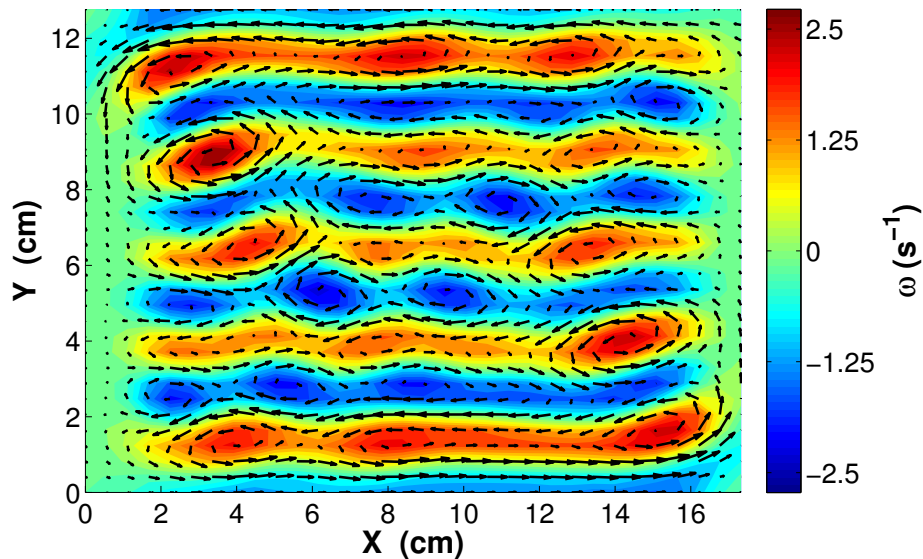


Turbulence with these B.C.'s look qualitatively different from the simulation.

Effects of Varying the BC's

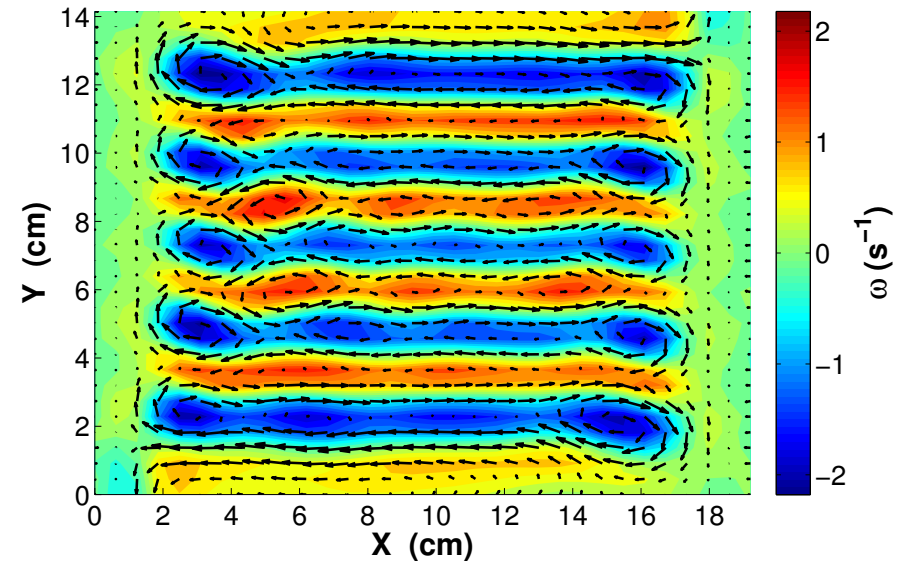
Close Electrodes, Far Sidewalls
Time-Averaged Flow Field (30 min)

Re = 29.8



Far Electrodes, Close Sidewalls
Time-Averaged Flow Field (30 min)

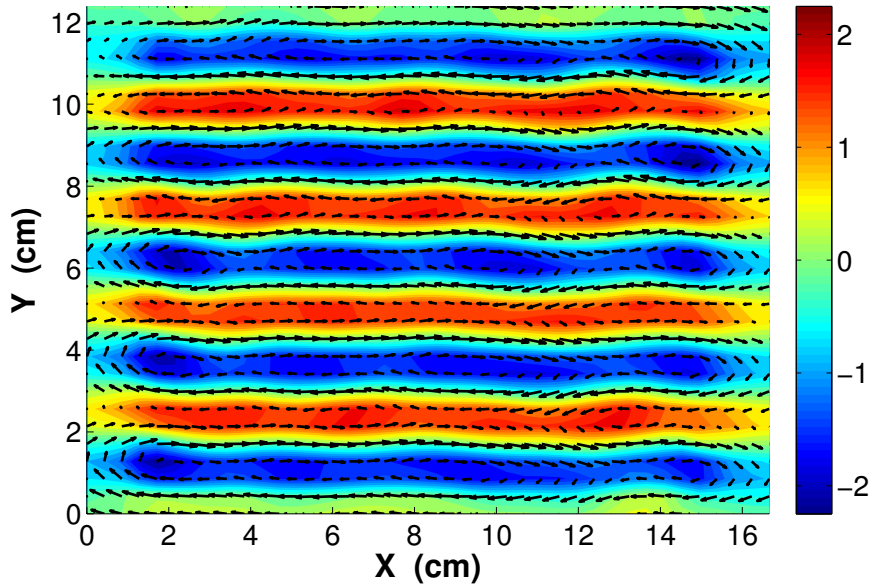
Re = 30.8



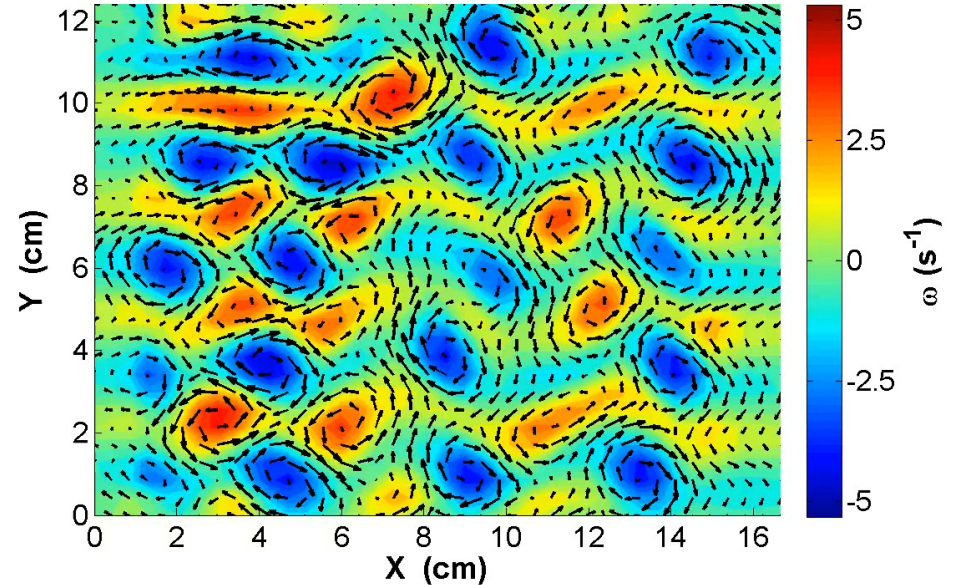
New Geometry

Time-Averaged Flow Field (30 min)

Re = 35



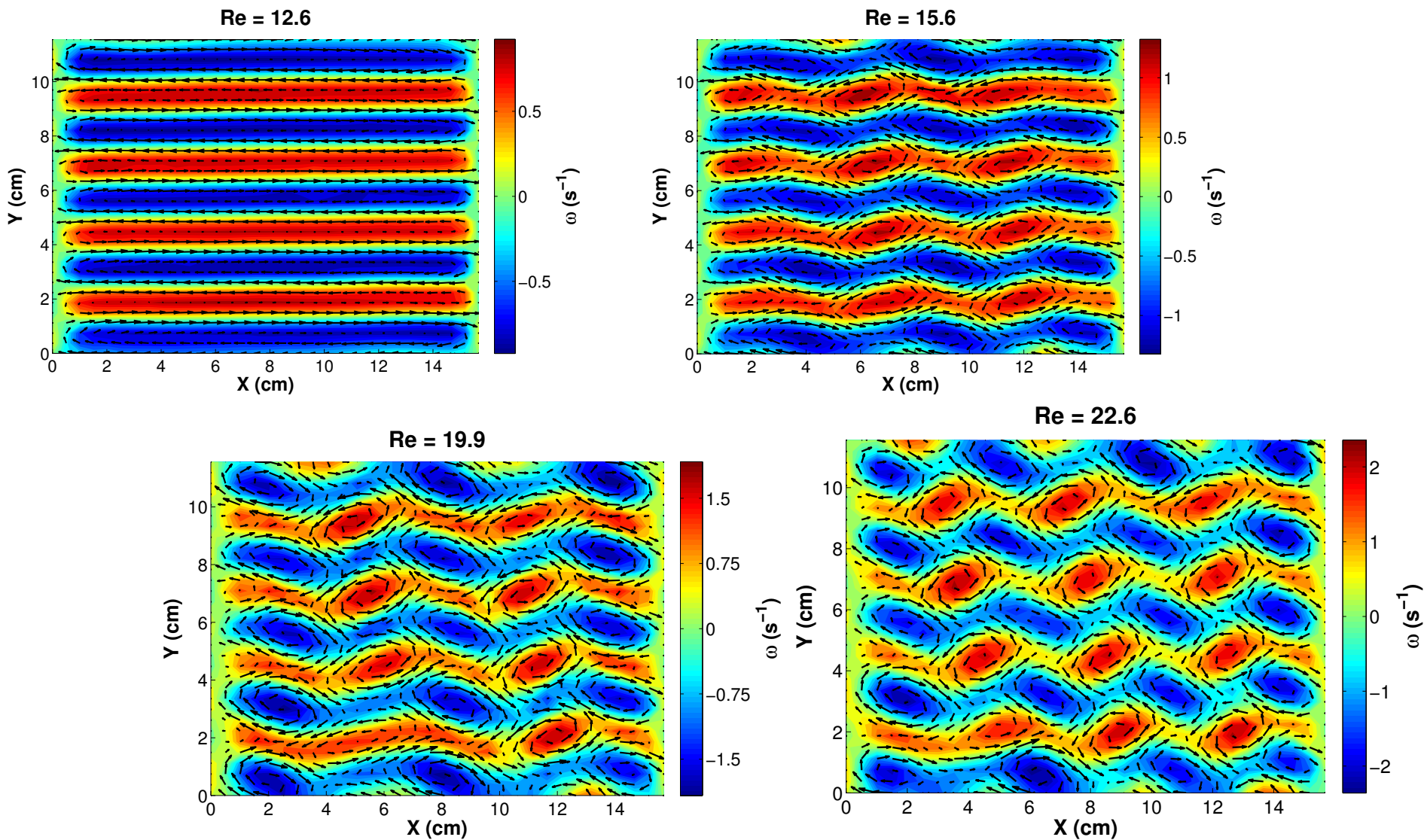
Re = 35 , Time: 0s



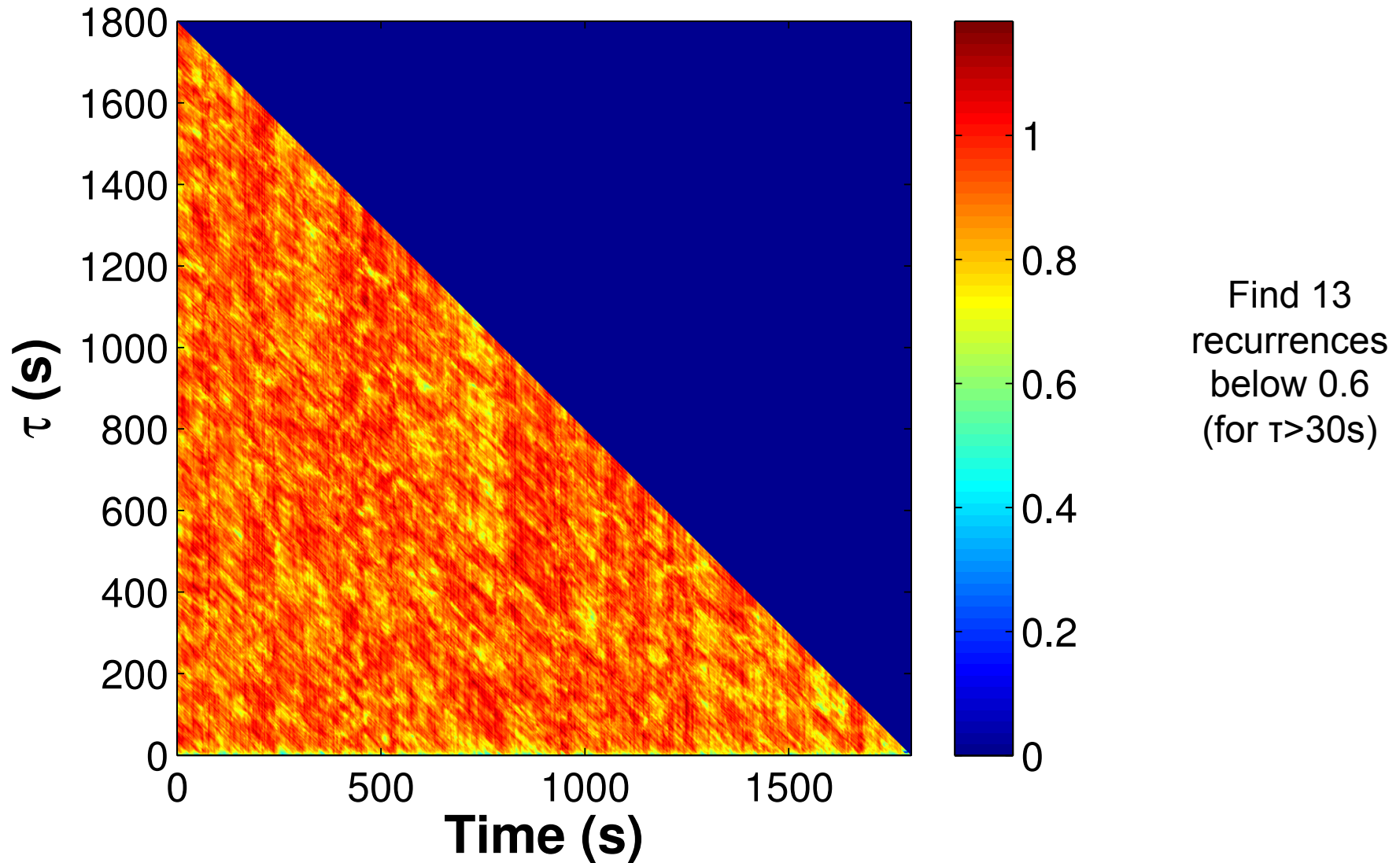
14 Magnet Setup
with $d_e = 2.54$ cm
and $d_s = 1.27$ cm

Bifurcations (New System)

14 Magnet Setup
with $d_e=2.54$ cm
and $d_s=1.27$ cm

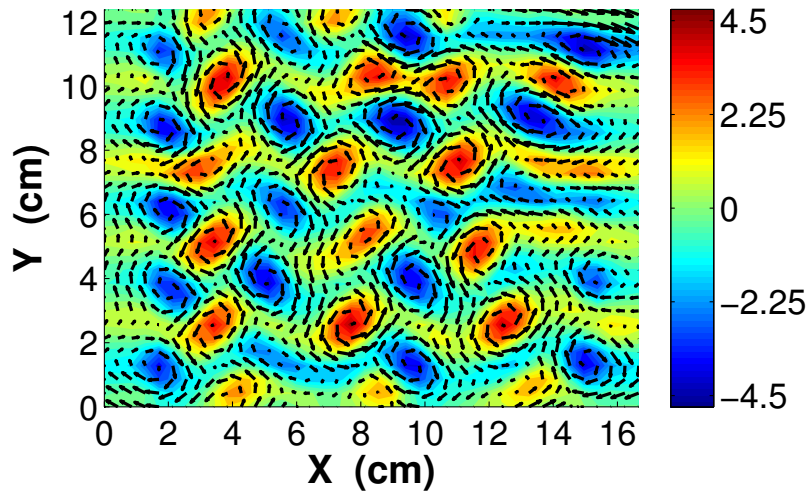


Full Flow Field Recurrence Search

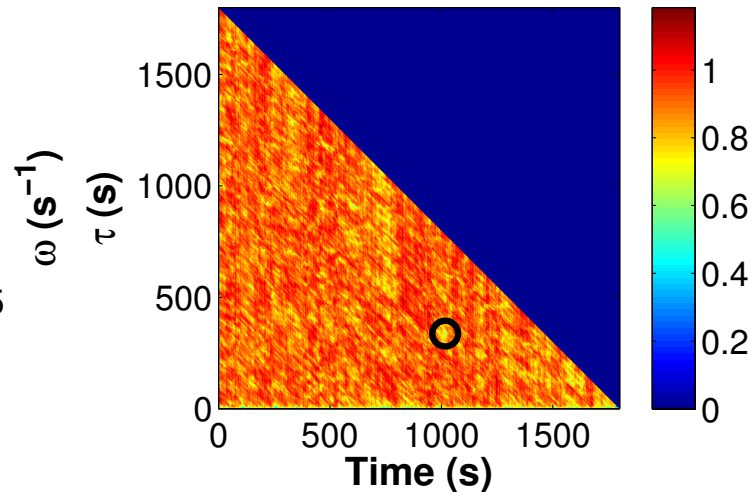


Full Flow Field Recurrence Search

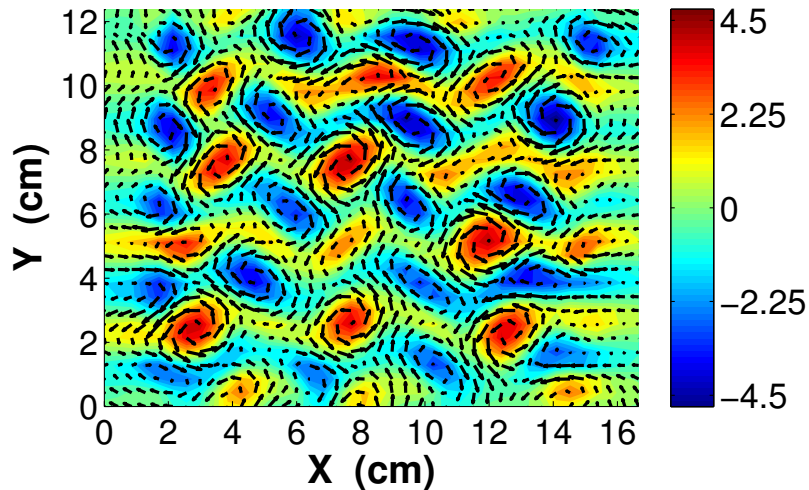
Frame 1017



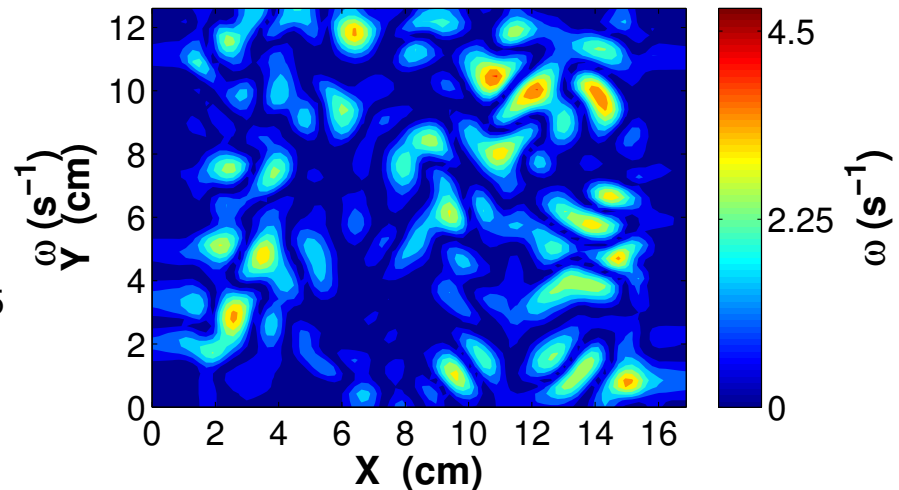
Recurrence Value of 0.57



Frame 1354

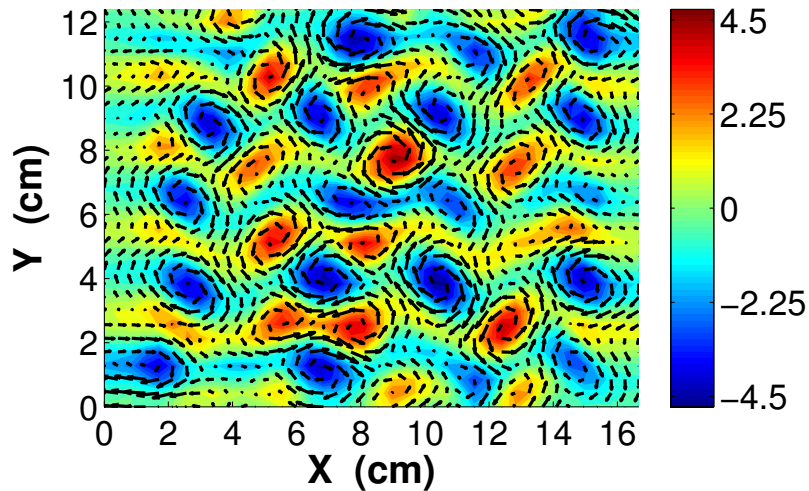


Magnitude of Difference in Vorticity

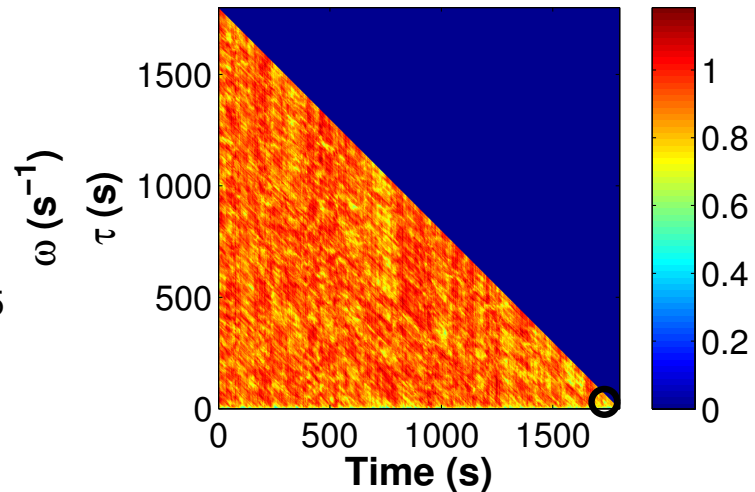


Full Flow Field Recurrence Search

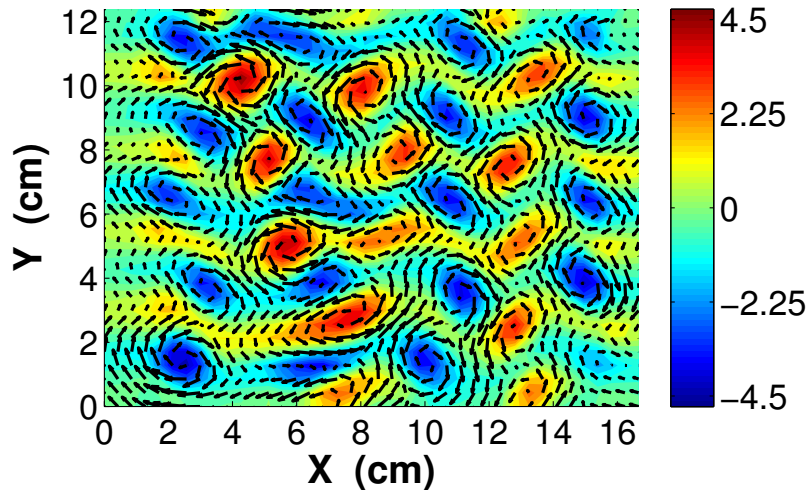
Frame 1732



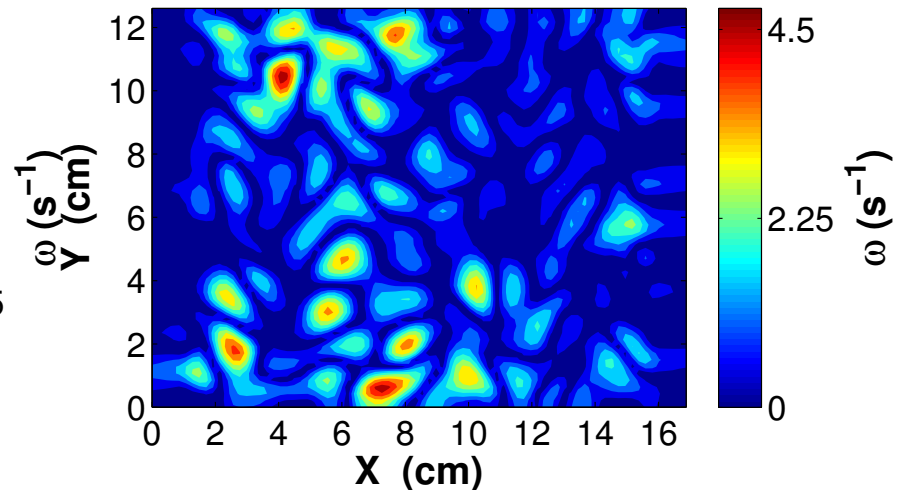
Recurrence Value of 0.58



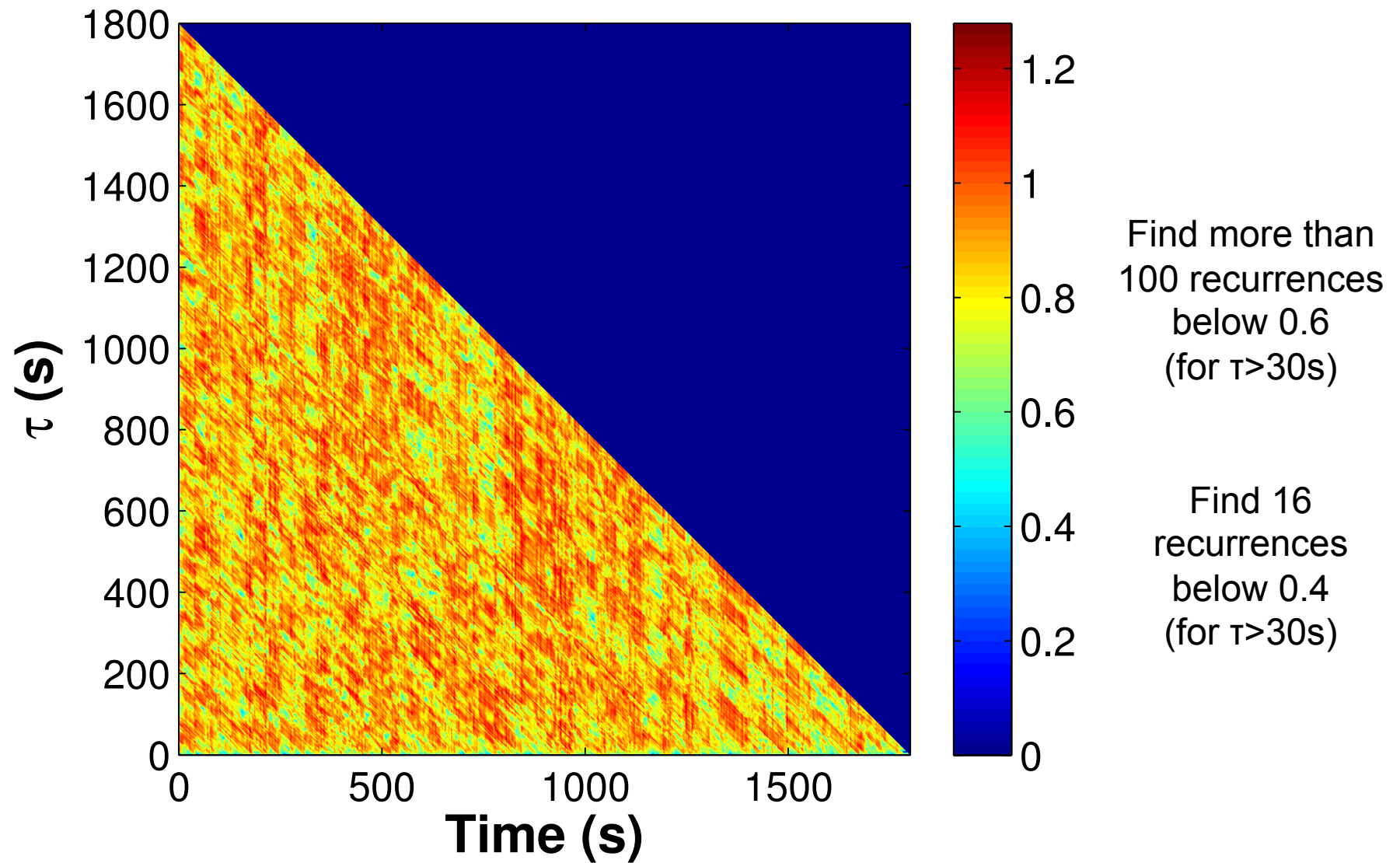
Frame 1762



Magnitude of Difference in Vorticity

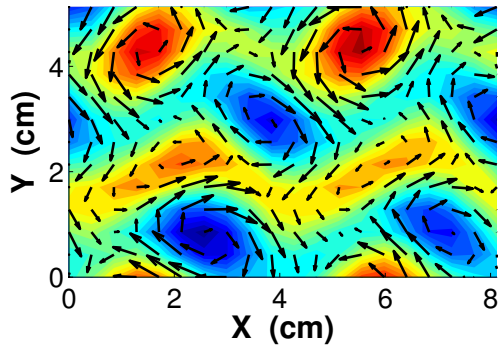


“Unit Cell” Recurrence Search

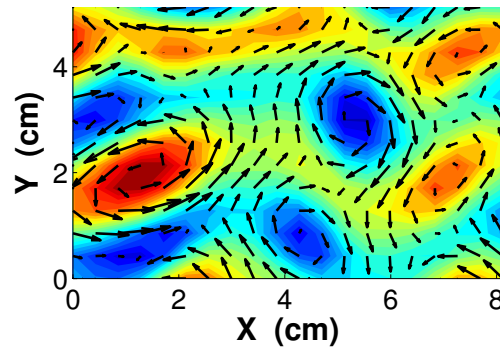


“Unit Cell” Recurrence Search

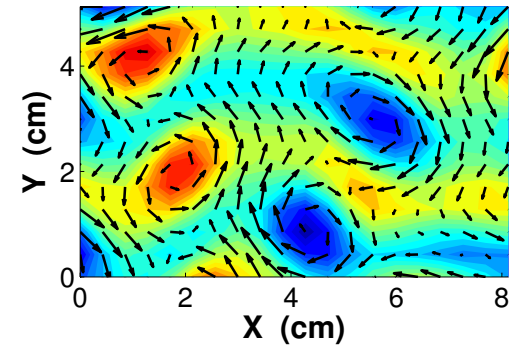
Frame 57



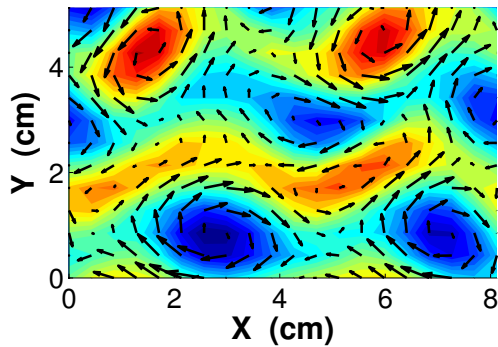
Frame 119



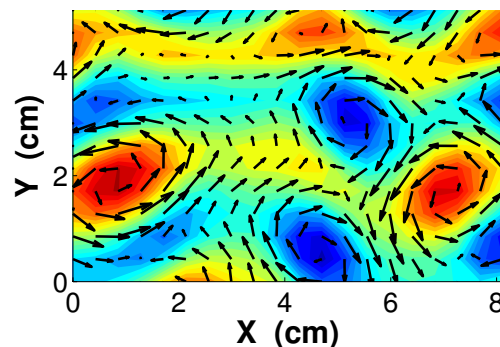
Frame 154



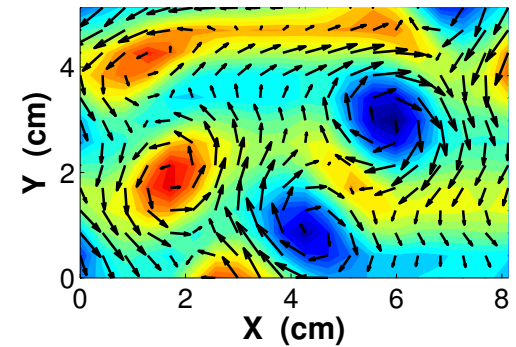
Frame 848



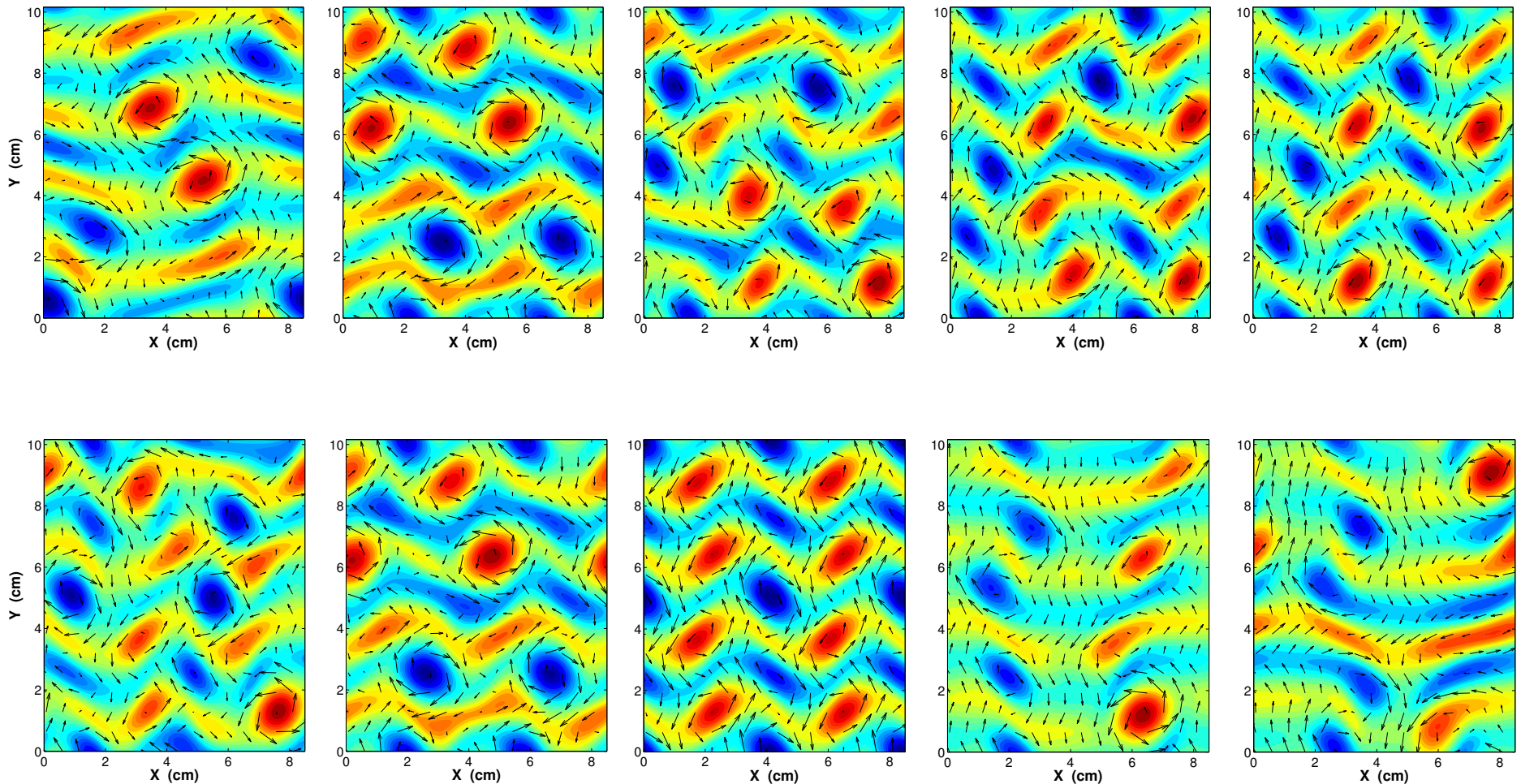
Frame 993



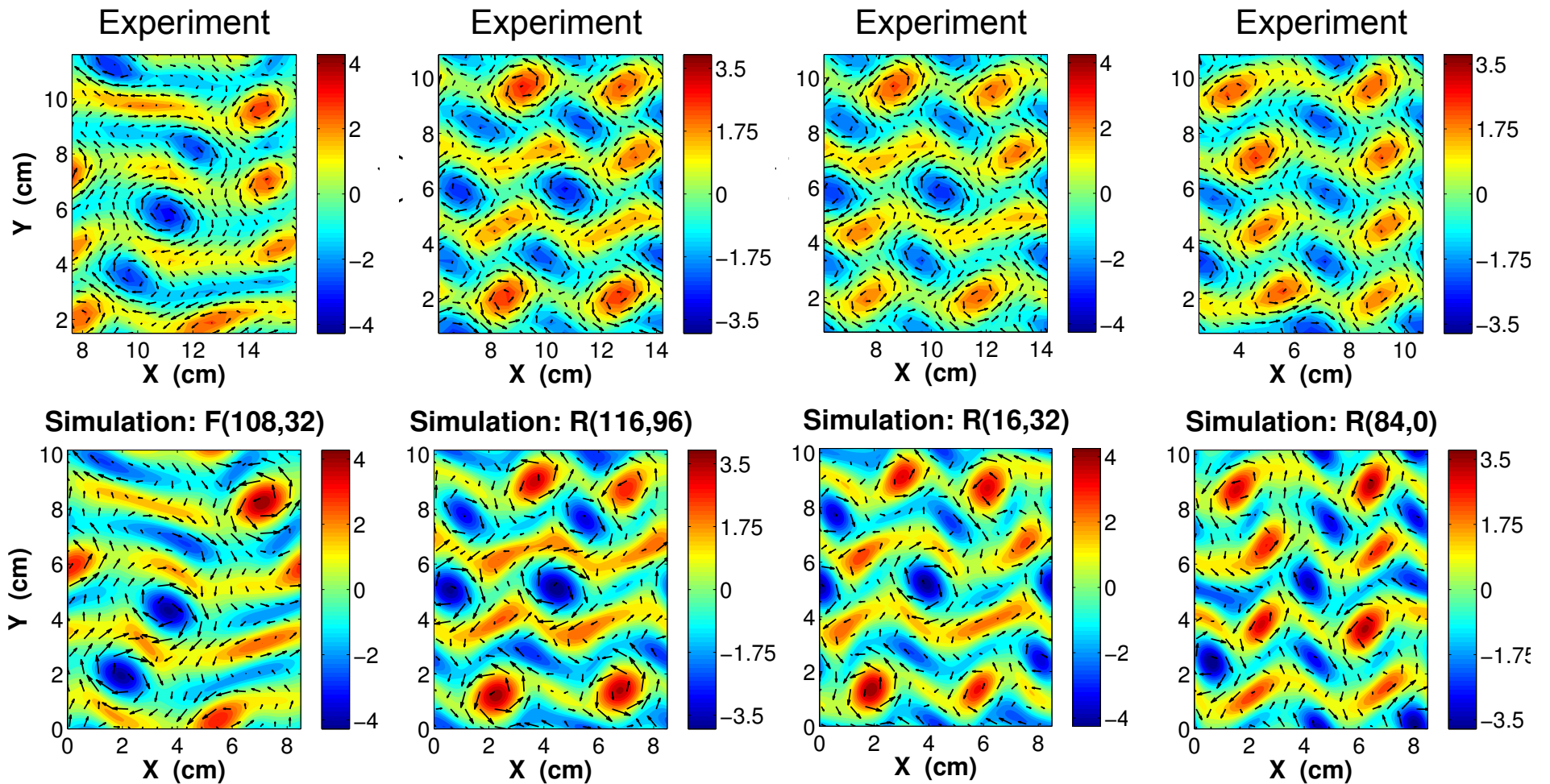
Frame 696



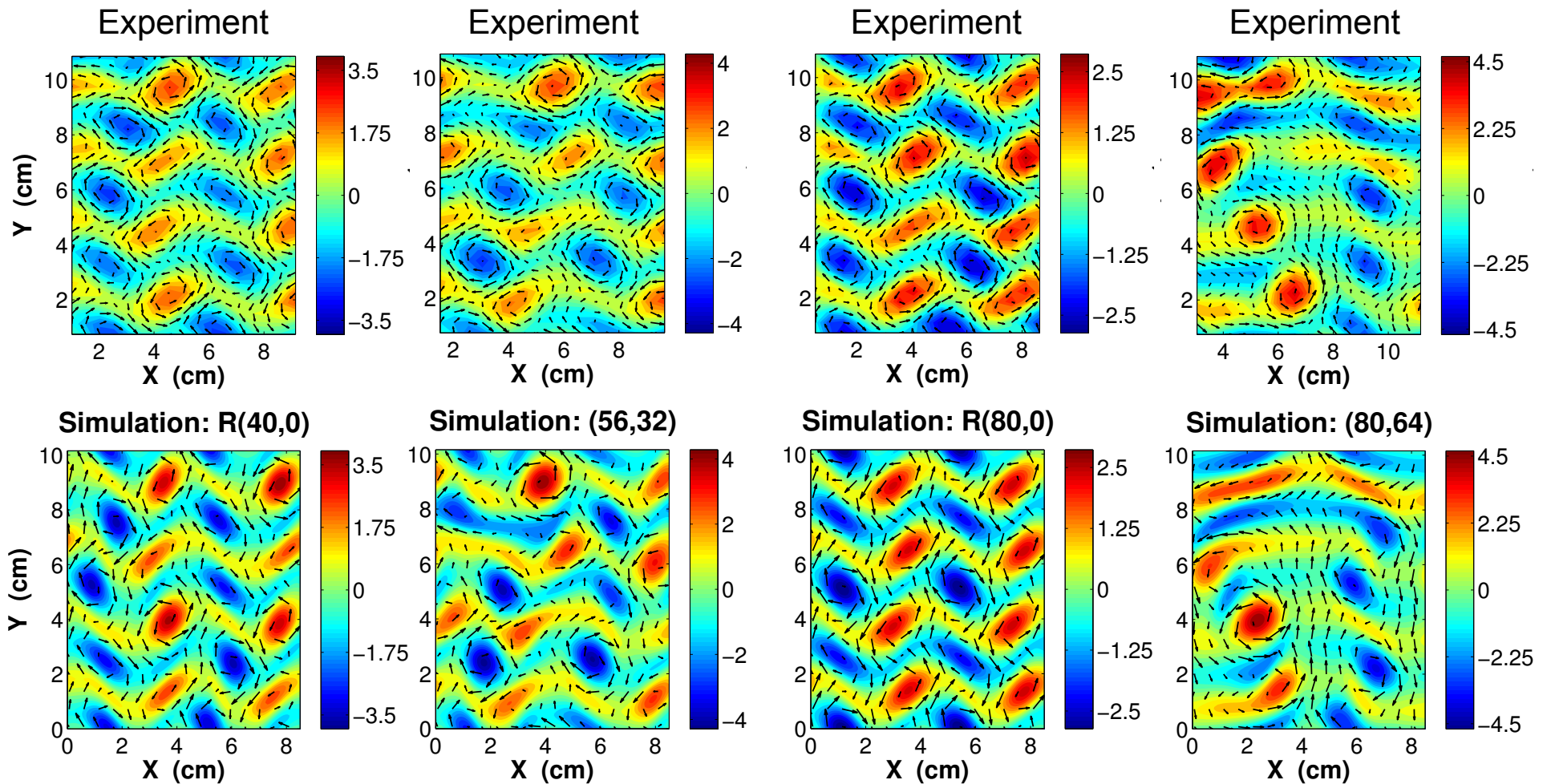
Invariant Solutions (Doubly-Periodic Simulation, 8 Magnets, 8.50 cm Wide)



Experiment-Simulation Close Recurrences



Experiment-Simulation Close Recurrences



Ideas For Characterizing Recurrences

- Statistics for finding invariant solutions vs. a random state
- Does the experiment spend a “long” time near that solution?
- Perturb the (unstable) invariant solution in a direction calculated from experiment; is time-evolution similar?