Generalized Synchronization of Spatiotemporal Chaos

Rita Kalra, Elizabeth Rogers*, Atsushi Uchida*, and Rajarshi Roy*

Stony Brook University
*University of Maryland at College Park
Overview

- Motivation: Generalized Synchronization
- Our Nonlinearity: Liquid Crystal Spatial Light Modulator
- Experimental Setup: Opto-electronic feedback loop
- Experimental Results
  - Observation of Generalized Synchronization
  - Parameter Dependence of Synchronization
- Summary
Generalized Synchronization (GS)

- What is it?
  - Functional relationship between drive and response:
    \[ y(t) = F(x(t)) \]

- How is it determined?
  - Auxiliary system approach:
GS of Spatio-temporal Chaos

Drive Pattern

Response Patterns
Liquid Crystal Spatial Light Modulator (SLM)
Liquid Crystal Spatial Light Modulator (SLM)

- Nonlinear Element in Experiment
- Computer-Controlled
  - takes VGA signal from computer, displays intensity image on an LCD within the SLM
- Intensity patterns modulated by liquid crystal inside SLM
- Bias Voltage-Controlled
  - varies amount and speed of deflection of liquid crystal molecules
    - speed at which liquid crystals molecules deflect is additionally controlled by speed of external (spatiotemporal) drive signal
  - controls feature size
Experimentation

- Created drive and response movies using closed and open-loop configurations
  - bias voltage mismatch
- Gave each response movie different initial conditions
  - initial conditions determined by the last image left on SLM
  - each response began from different frame of drive movie
Experimental Setup

- Computer
- Laser
- SLM
- Lens
- Lens
- Polarizer
- Rotator
- Polarization
- Pinhole
- Bias Control
- CCD Camera
- Mirror
- Mirror
GS of Spatiotemporal Chaos

Drive Pattern

Response Patterns
Synchronization Error vs. Time for Drive Signal at 1.50V
Bias Voltage Dependence of Sync. Time & Sync. Error

Transients Time (Frame Number) vs. Bias Detuning (Volts)

Synchronization Error (dB) vs. Bias Detuning (Volts)
X, Y Autocorrelation of Grain Size for Responses at Different Bias Voltages

**X Autocorrelation**

Normalized Intensity (AU) vs Distance (Pixels)

**Y Autocorrelation**

Normalized Intensity (AU) vs Distance (Pixels)
Summary

- We have demonstrated generalized synchronization of spatio-temporal chaos in an opto-electronic feedback loop using a liquid crystal Spatial Light Modulator.
- Different initial conditions of responses caused transients to occur before synchronization.
- Synchronization showed parameter dependence on bias voltage:
  - synchronization time varied inversely with bias voltage.
  - synchronization error did not vary much with bias voltage: once responses synchronized, they stayed synchronized.
- Auto-correlation length plots show grain size dependence on bias voltage.