Information Transfer in Spatially Extended Systems

2a. *Goal*: What is your primary project goal? What you would like to learn?

The goal of my project is to explore the information transfer in spatially extended systems. I am interested in this question because it is abstractly similar to a question I need to answer in my own research—mainly, if I can safely ignore distant changes when trying to answer a question about local dynamics.

2b. *System*: Describe how the dynamical system is nonlinear and time-dependent.

The system I am studying is the Belousov-Zhabotinsky reaction. This reaction produces a complex pattern of colors that are dependent on the concentrations of the chemicals at a particular point in space.

What's the state space?

Depending on the model used, the state space of the system can vary. If the Greenberg-Hasting model is used then each cell in the spatially extended system will have its own variable, and the variable can take on three values, {0,1,2}.

What's the dynamic?

In the Greenberg-Hastings model the dynamic is that locally if the value is 1, it will change to 2, and if the value is 2, it will cycle back to zero. However, if the value is 0, then the next value will depend on its neighbors.

In the real system, points emit traveling waves periodically and interfere with each other.

Why is the system behavior interesting?

They system is interesting because of the complex patterns that can emerge from simple starting material. The B-Z reaction is an autocatalytic reaction, and this sort of reaction.

2c. *Dynamical properties*: What dynamical properties are you going to investigate?

The main dynamical property I want to investigate is the time evolution of the states in the spatially extended system.

2d. *Intrinsic computation properties*: What information processing properties are you going to investigate?

The main intrinsic computation property I am investigating will be the mutual information between spatially extended points in the system. Beyond that the block entropies, and other information measures may be investigated.

2e. *Methods*: What methods will you use? Why are they appropriate?

There are two tracks of investigation I would like to pursue. One is creating a computer model of the B-Z reaction, the other is doing the B-Z reaction in a petri dish or something similar.

The computer model will have fewer administrative hurdles since I work in a computational chemistry group. Doing the physical experiment will require me finding people that can part with different starting material.

2f. *Hypothesis*: What is your current guess as to what you will find?

From some of the conversation with Jim, I expect to find that the information transfer will happen at a maximum rate along "light cones" in the reaction. I believe in the actual reaction, this will determine the maximum speed of the traveling waves.

2g. *Steps*: List the appropriate steps for your investigation; for example, read literature, write simulator, do mathematical analysis, estimate properties from simulation, write up report, and so on.

Computational track:

1) Code the Greeberg-Hastings model. Simulate with multiple starting states.
2) Add a way to keep track of block entropies
3) Add a way to keep track of mutual information
4) Make plots of this information

Experimental Track:

1) Track down sources for the reactants that can be used in a recipe. There is a list of recipes by Janke and Wilfre 1991.
2) Get a camera set up in a situation approved by chemistry department
3) Either tape or demonstrate the reaction

2h. *Time*: Estimate how long each step will take. Can you complete the project within one month?

I believe each of the steps in the computational track will take less than a week, and the experimental track can happen in parallel, but may be more likely to fail.