Complex Dynamical Systems

Most mathematical models in the sciences.

Chief characteristic features:

Chaotic behavior
Bifurcations
Indeterminacy

Meeting #1T, April 4

- Chaos and indeterminacy

- Course organization

- Begin with 1D iterations

Chaos and Indeterminancy

- Two butterfly effects
  - Sensitivity
  - Bifurcations

Steve Smale, 1996

Chaos is a new science which establishes the omnipresence of unpredictability as a fundamental feature of common experience.

A belief in determinism, that the present state of the world determines the future precisely, dominated scientific thinking for two centuries. This credo was based on certain laws of physics, Newton's equations of motion, which describe the trajectories in time of states of nature. These equations have the mathematical property that the initial condition determines the solution for all time. Thus lies the mathematical and physical foundation for deterministic philosophy. One manifestation of determinism was the rejection of free will and hence even of human responsibility.

Steve Smale, 1996

In the 1970s the scientific community recognized another revolution, called the theory of chaos, which deals a death blow to the Newtonian picture of determinism. As a consequence, the world now knows that one must deal with unpredictability in understanding common experience. The coin-flipping syndrome is pervasive. "Sensitive dependence on initial conditions" has become a catchword of modern science.

Course organization

- Class times

- Lab assignments

- Grading

Class Times

- Meetings will begin at 9:50 am, and end by 11:25 am

- Meetings wull usually begin with calling the roll or sometimes a quiz

Lab assignments

- Weekly lab assighments will be posted online every Friday morning,and due the following Friday at 9 am.

- Lab results must be posted online on-time to be scored.

- Math software: NetLogo and p5.js

- Web software: HTML, CSS, JavaScript

Grading

- Pop quizes

- Lab/homework posted on personal websites

- Final exam

Chaos Theory

- Chaos and fractals

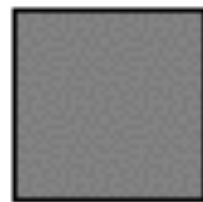- Stairway to chaos

- 1D experiments
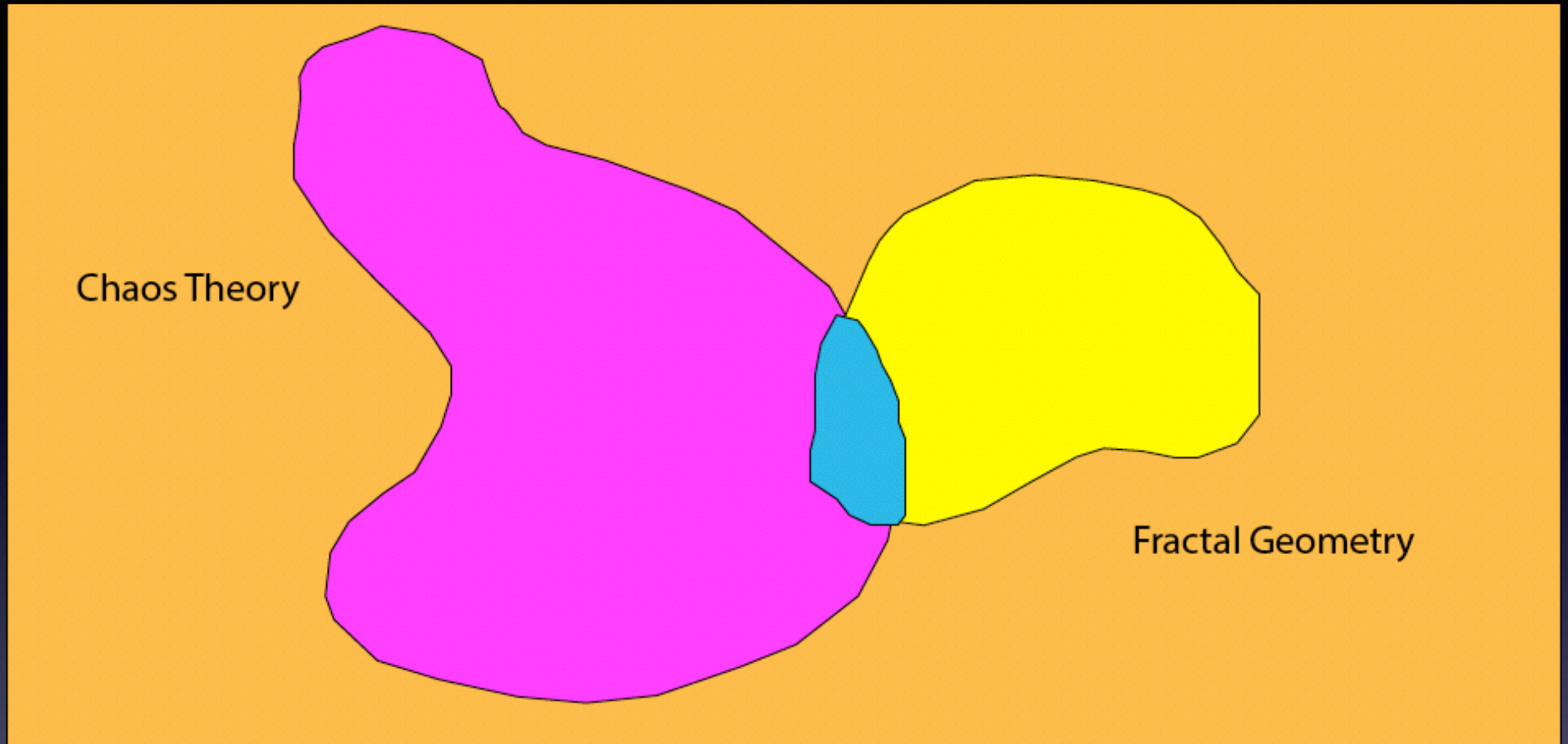
Chaos and Fractals

The Stairway to Chaos

Chronology

- 1946, Macy Conferences (cybernetics)

- 1957, Beverton and Holt (1D iterations)

- 1958, Myrberg (2D iterations)

- 1960, Smale horseshoe (2D cascades)

- 1961, Ueda attractor (3D flows)

- 1966, Thom catastrophe theory (1D flows)

- 1972, IIASA (complex dynamical systems)

- 1974, Li and Yorke, May (the chaos revolution)

Math 145 Spring 2017 Meeting #1T

On to 1D Experiments