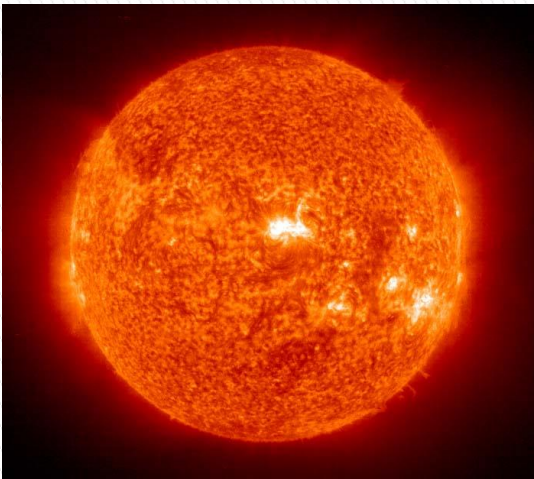




Quiz Time!

# What do these have in common?



Sun

Soaring

Cooking

# This familiar set of equations

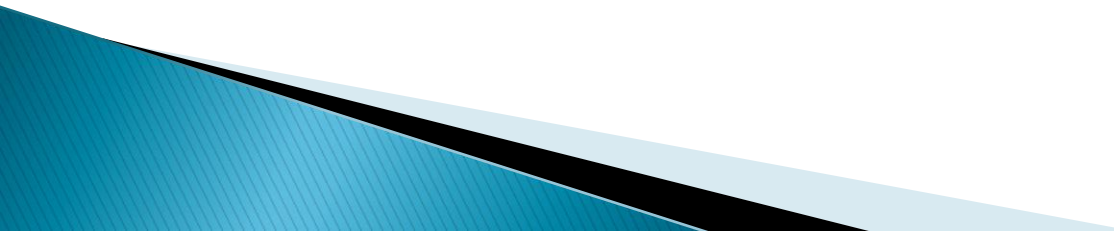
$$\dot{X} = -\sigma(X - Y)$$

$$\dot{Y} = -Y - ZX + rX$$

$$\dot{Z} = -bZ + XY$$

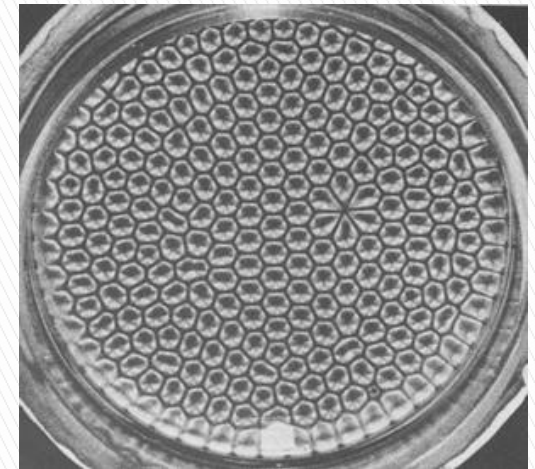
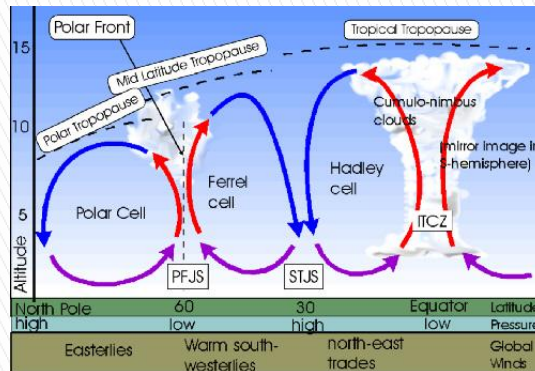
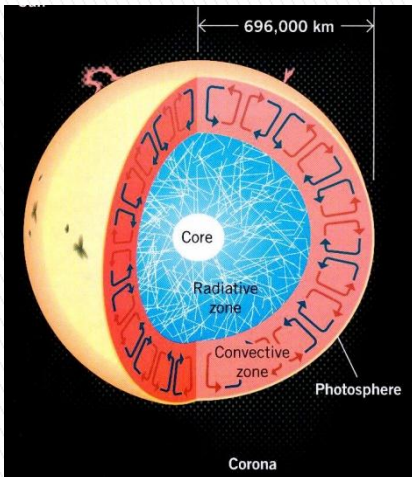
# The Lorenz system in 6D

# Outline

- ▶ Introduction of the Topic
  - ▶ Derivation
  - ▶ Explanation
  - ▶ Project Outline
  - ▶ The First Steps
  - ▶ Current Status
  - ▶ Next Steps
  - ▶ Plan B
- 



# Convective Flow

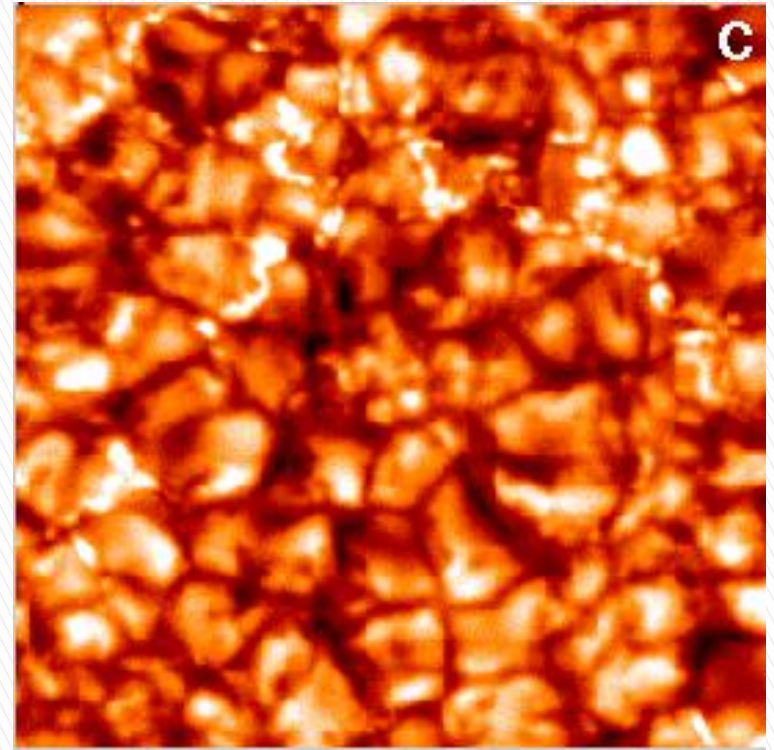
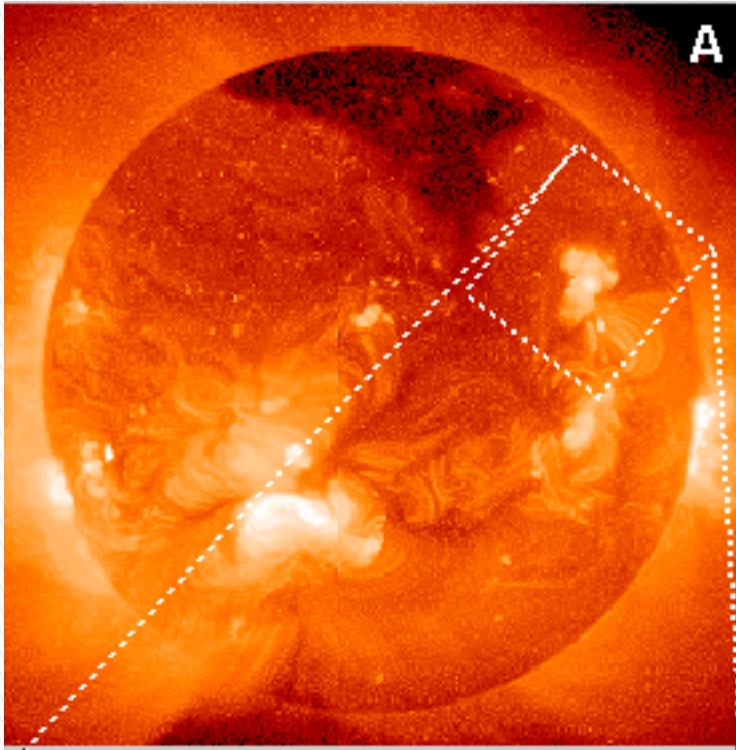


Sun

Soaring

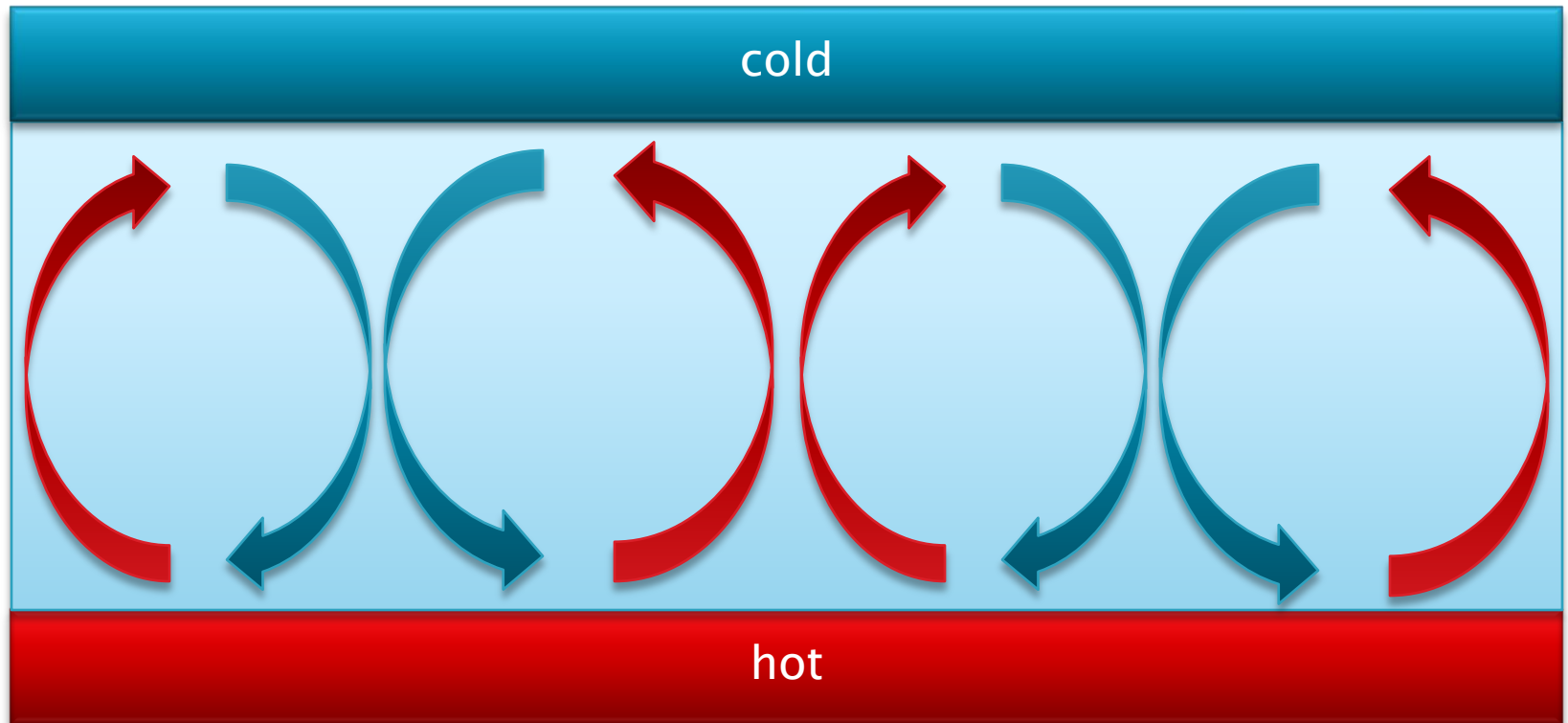
Cooking

# Sun convection cells

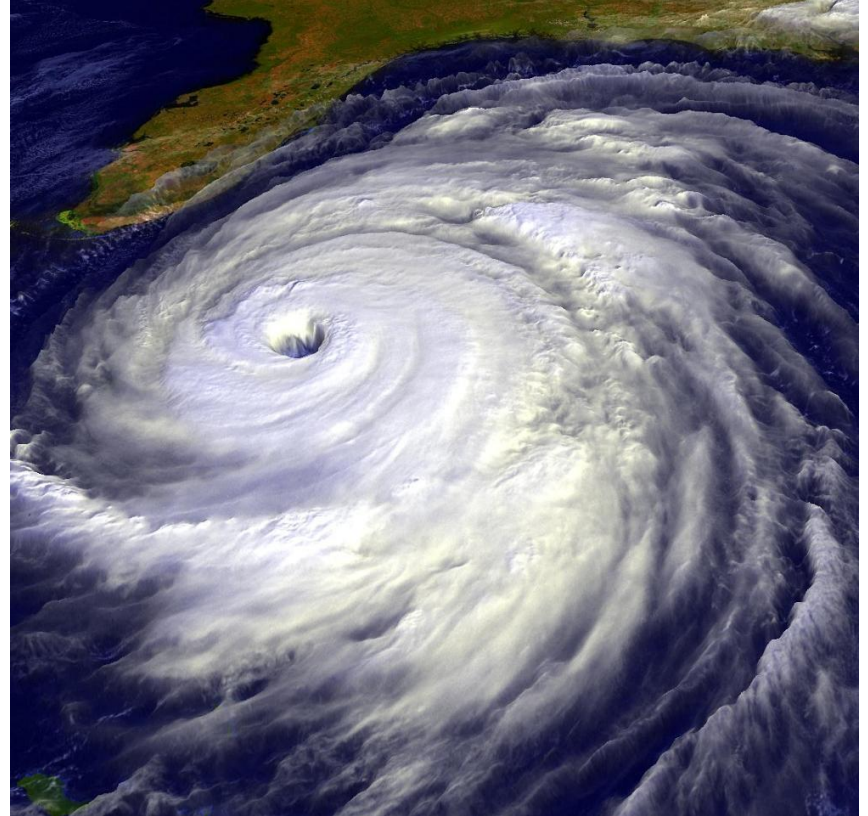




# Rayleigh–Benard Flow



# Why?



# How?

- ▶ Start with Navier–Stokes Equations

$$\frac{1}{\text{Pr}} \left\{ -\frac{\partial}{\partial t} \Delta \psi + \frac{\partial}{\partial z} \left( u \frac{\partial u}{\partial x} + w \frac{\partial u}{\partial z} \right) - \frac{\partial}{\partial x} \left( u \frac{\partial w}{\partial x} + w \frac{\partial w}{\partial z} \right) \right\} = -\Delta^2 \psi - \frac{\partial \theta}{\partial x}$$

$$\frac{\partial \theta}{\partial t} + u \frac{\partial \theta}{\partial x} + w \frac{\partial \theta}{\partial z} = \Delta \theta + Ra \cdot w$$

- ▶ Ansatz for Disturbance...

$$\psi(x, z, t) = \sum_{m=1}^{\infty} \sum_{n=0}^{\infty} \psi_{mn}(t) \sin(mqx) \cos(\pi(2n+1)z)$$

- ▶ ...and Temperature field

$$\theta(x, z, t) = \sum_{m=1}^{\infty} \sum_{n=0}^{\infty} \theta_{mn}^a(t) \cos(mqx) \cos(\pi(2n+1)z) + \sum_{m=0}^{\infty} \sum_{n=1}^{\infty} \theta_{mn}^b(t) \cos(mqx) \sin(2\pi nz)$$

# How?

- ▶ Apply Galerkin Method

$$\psi(x, z, t) = \sum_{m=1}^{\infty} \sum_{n=0}^{\infty} \psi_{mn}(t) \sin(mqx) \cos(\pi(2n+1)z)$$

- ▶ Make Transformations

- ▶ Result: System of ODEs for amplitudes

$$\dot{X}_i = f(X_i)$$

# What?

- ▶ Prandtl number

$$\text{Pr} = \sigma = \frac{\text{viscous effects}}{\text{thermal effects}}$$

- ▶ Rayleigh Number

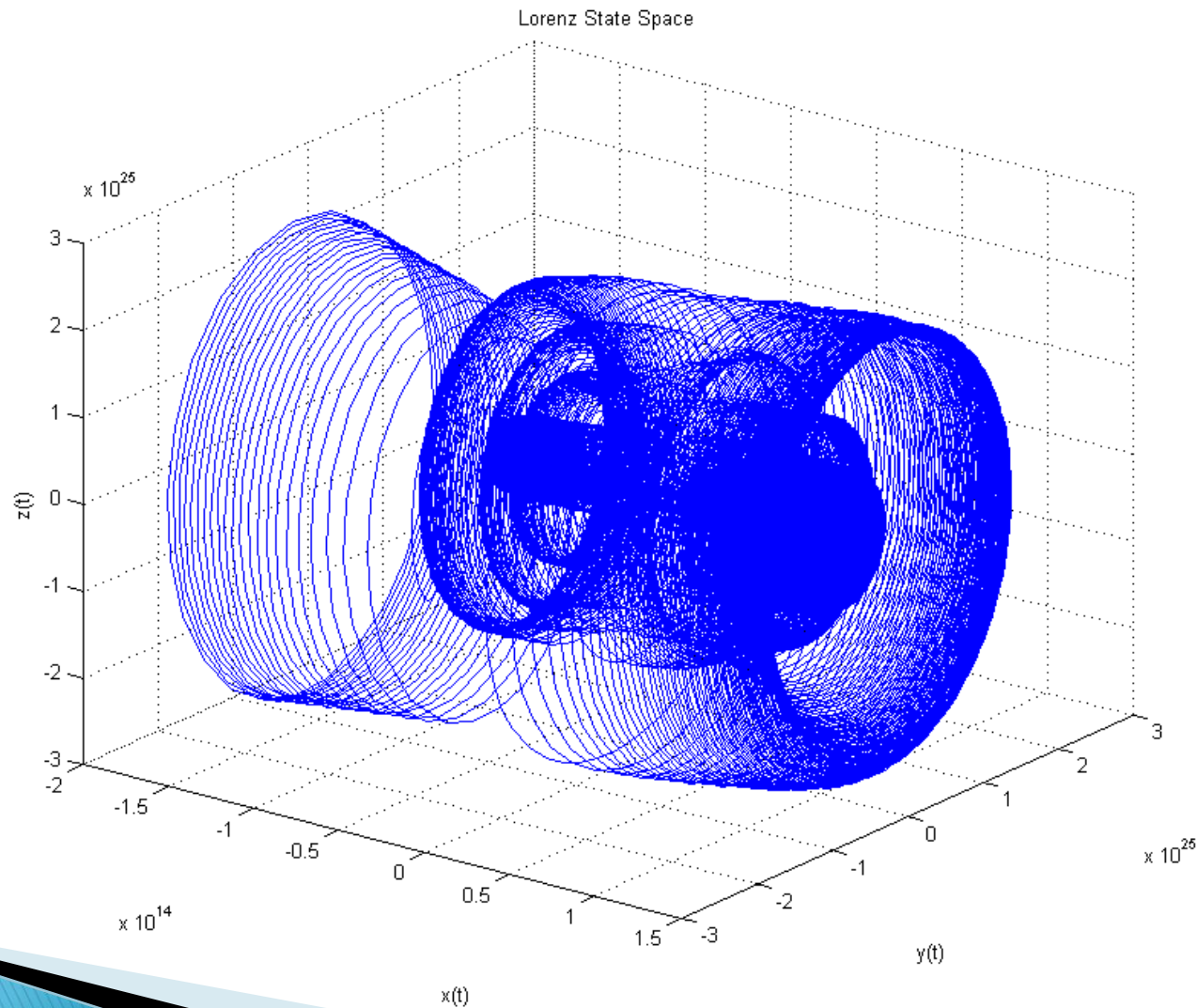
$$\text{Ra} = r = \frac{\text{buoyancy effects}}{\text{thermal effects}}$$



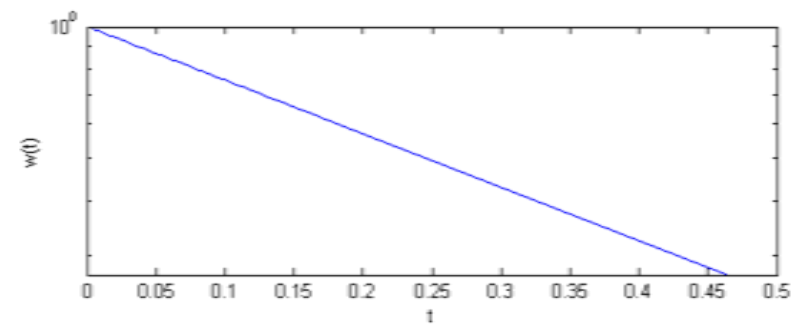
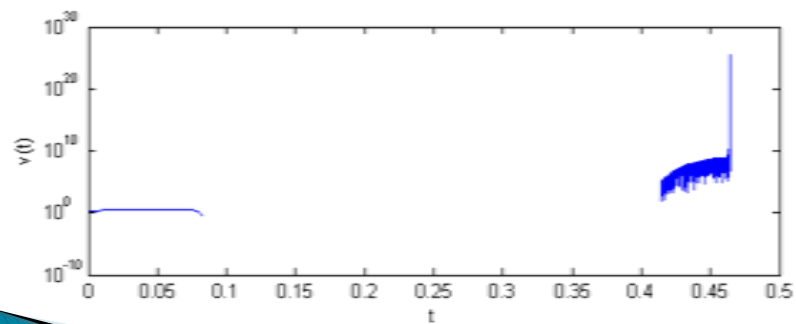
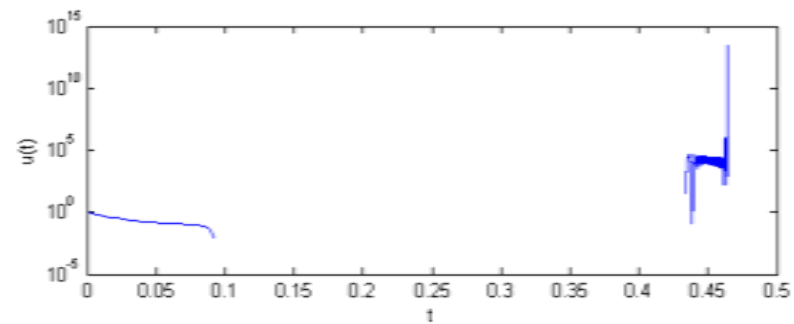
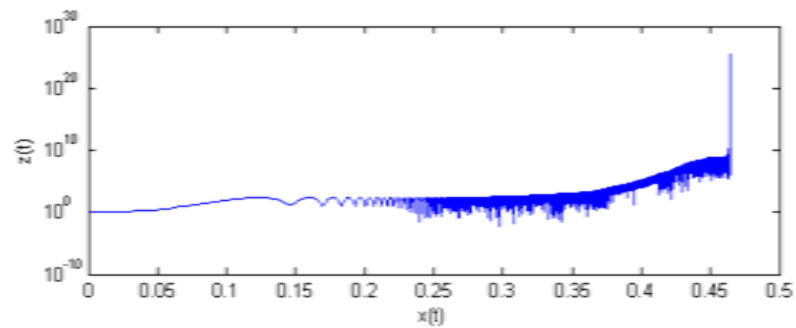
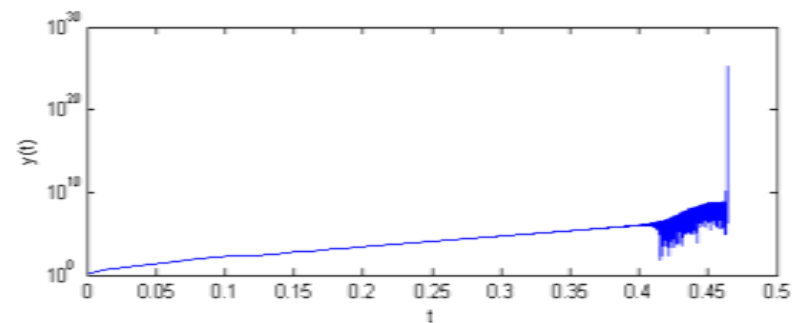
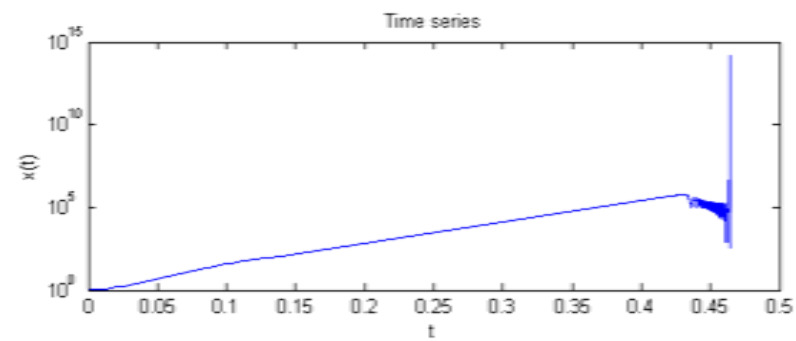
# Project Outline

- ▶ Extend number of modes
- ▶ Analyze emerging Dynamical System
- ▶ Extract Poincare Return Map
- ▶ Analyze PRM with means of Information Theory

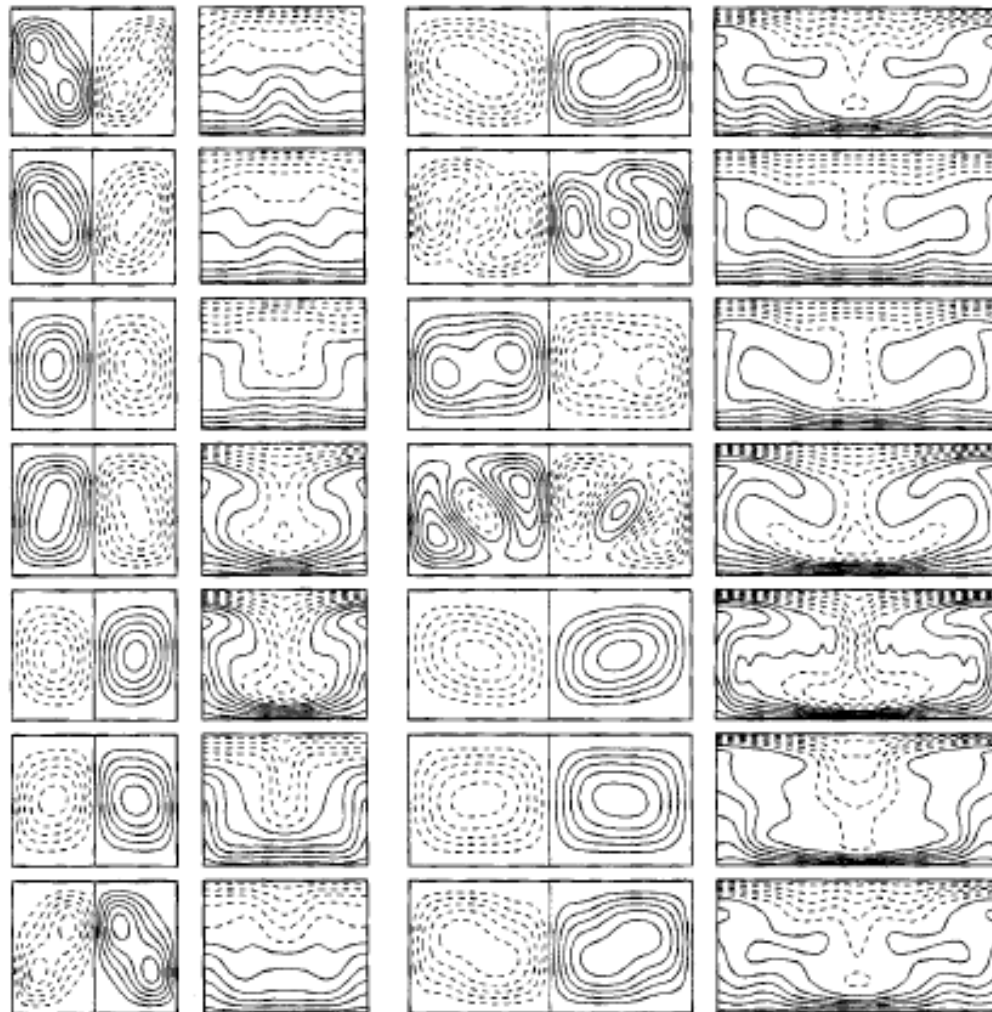
# First systematic attempt ...



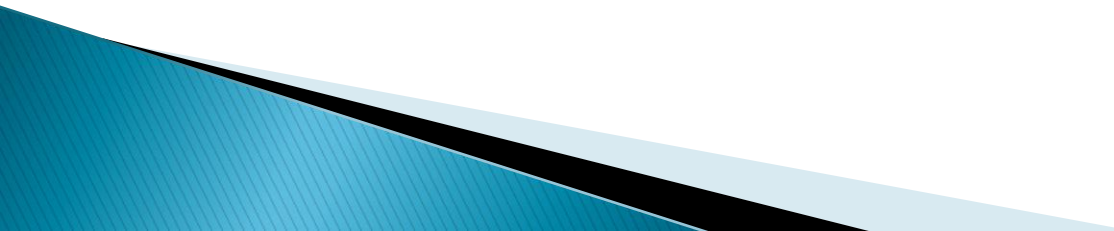
... fails



# New intelligent approach

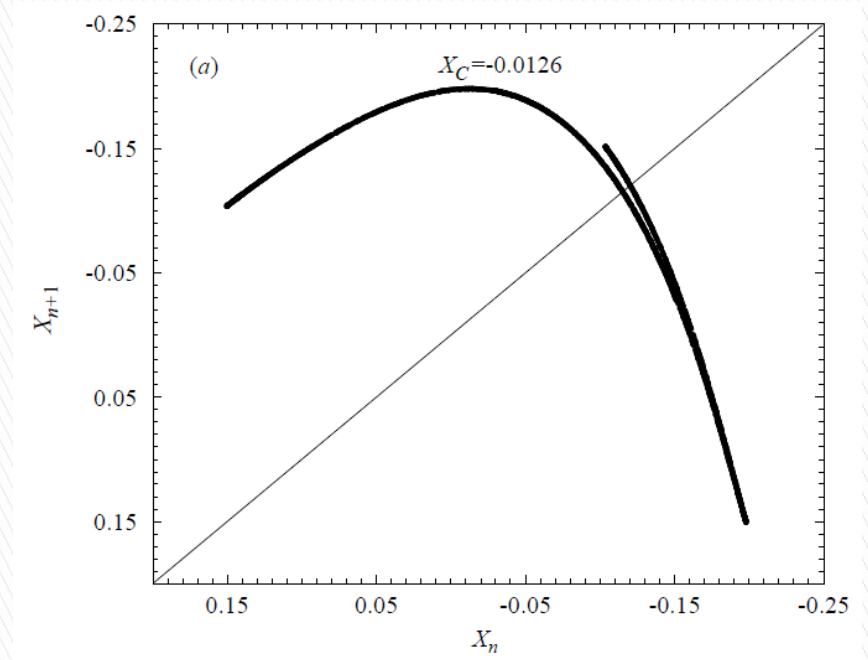
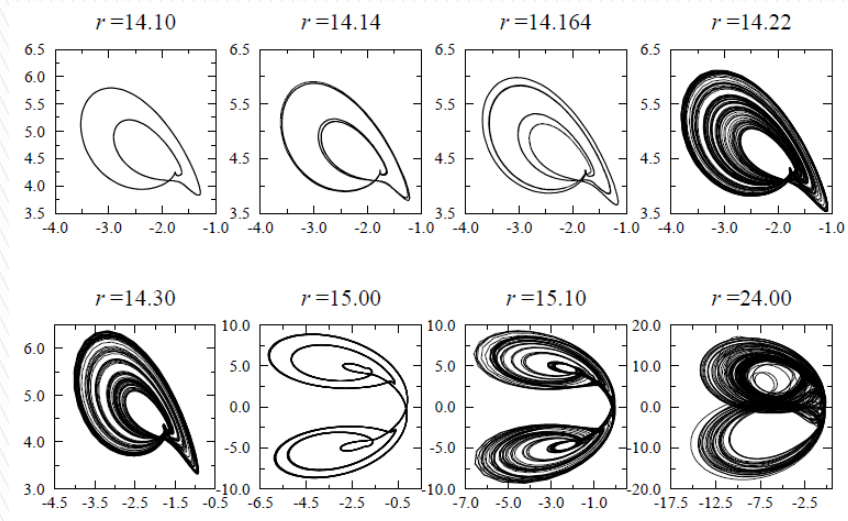


# Next Steps

- ▶ Research scan
  - ▶ Calculating the equations: Transition from Maple to Matlab (Maple)
  - ▶ Simulating the resulting Flow and Temperature field
  - ▶ Go on: Analysis ...
- 



# Plan B





Questions?

# Thank you!

**DON'T PANIC**



# Animation of Rayleigh Benard

