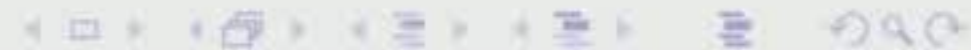


# Small Organisms Making Big Problems: Modeling Heterosigma Akashiwo

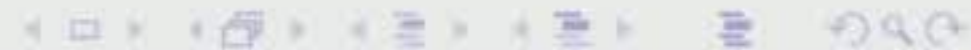
**Nicholas Russell**

Research with Dr. Louis Rossi  
University of Delaware  
May 21, 2019

# Harmful Algal Blooms



# Harmful Algal Blooms



# Our Lab



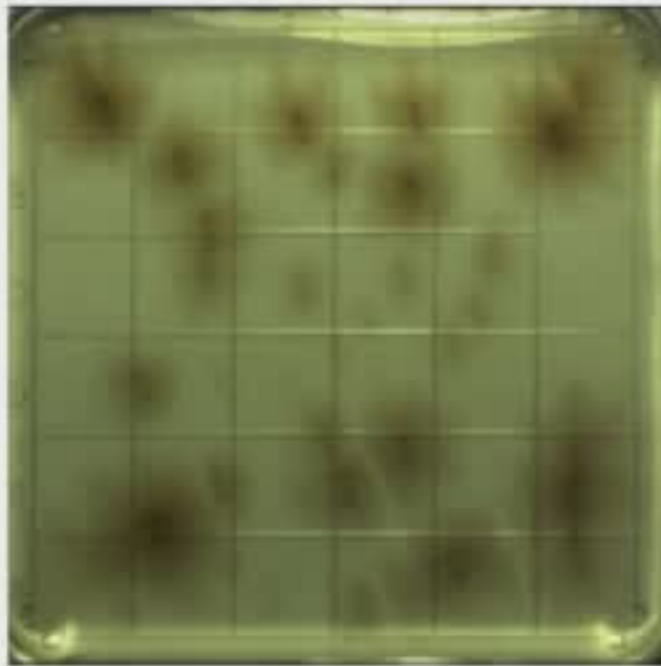
# Example Experiment



# Example Experiment



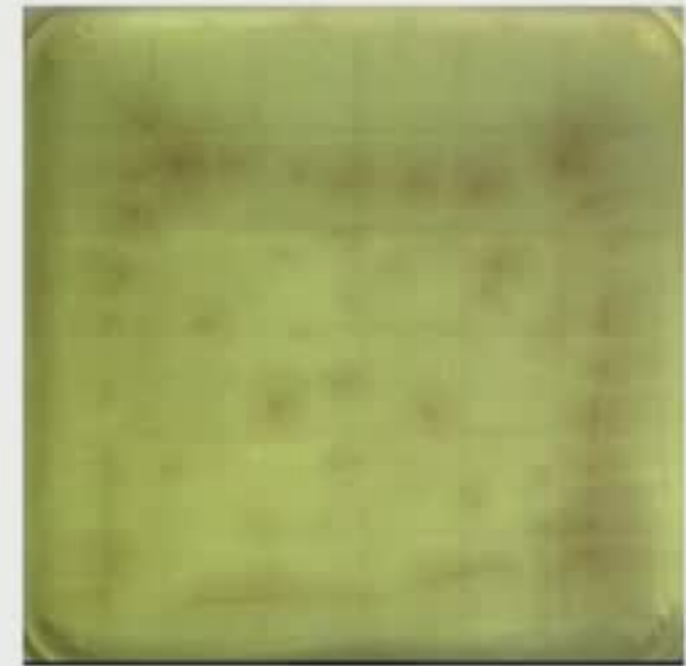
# Intensity of Light



High Intensity



Low Intensity



Darkness

# Depth



100%



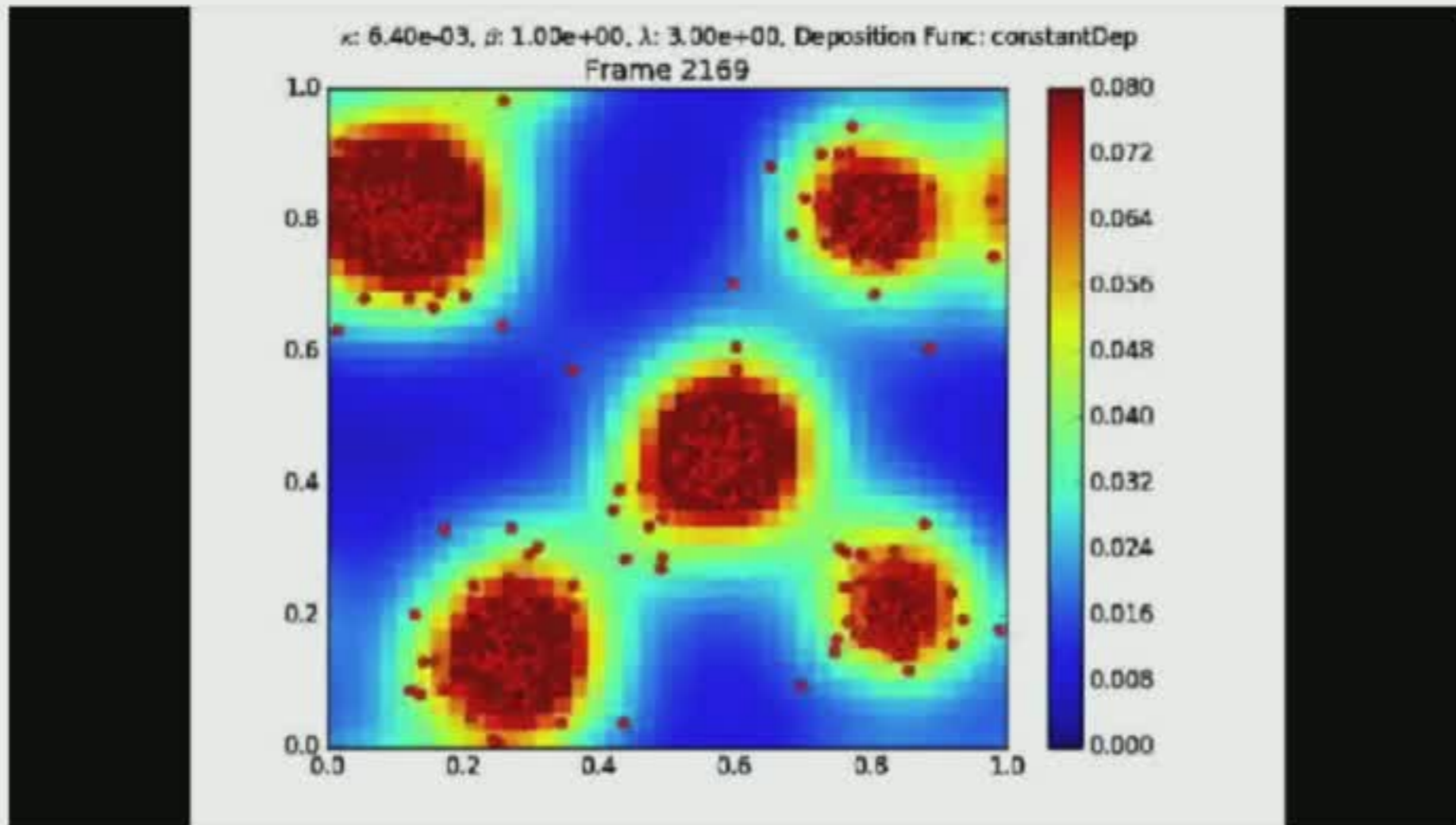


# Depth



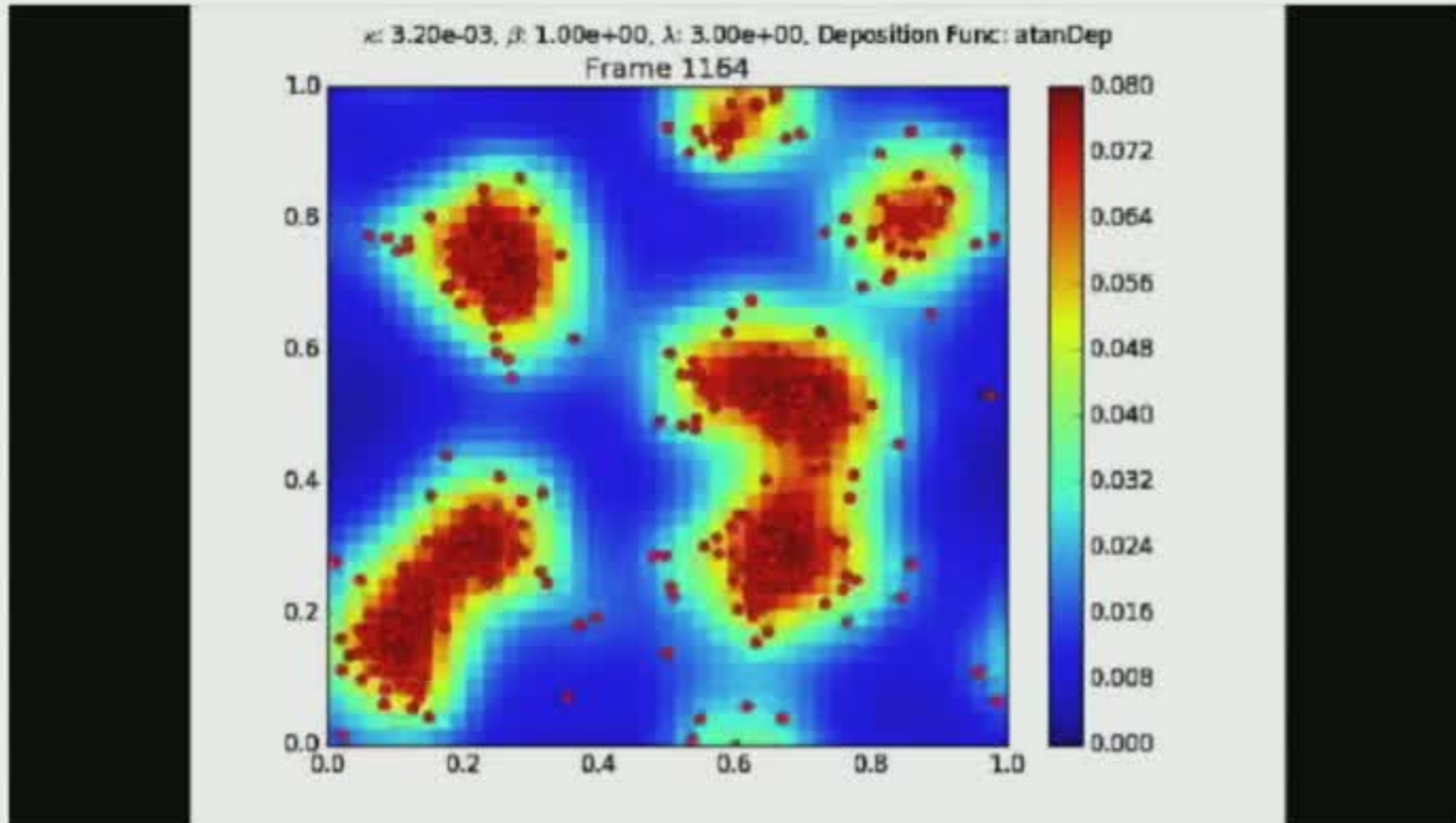
# Computational Experiment: Constant

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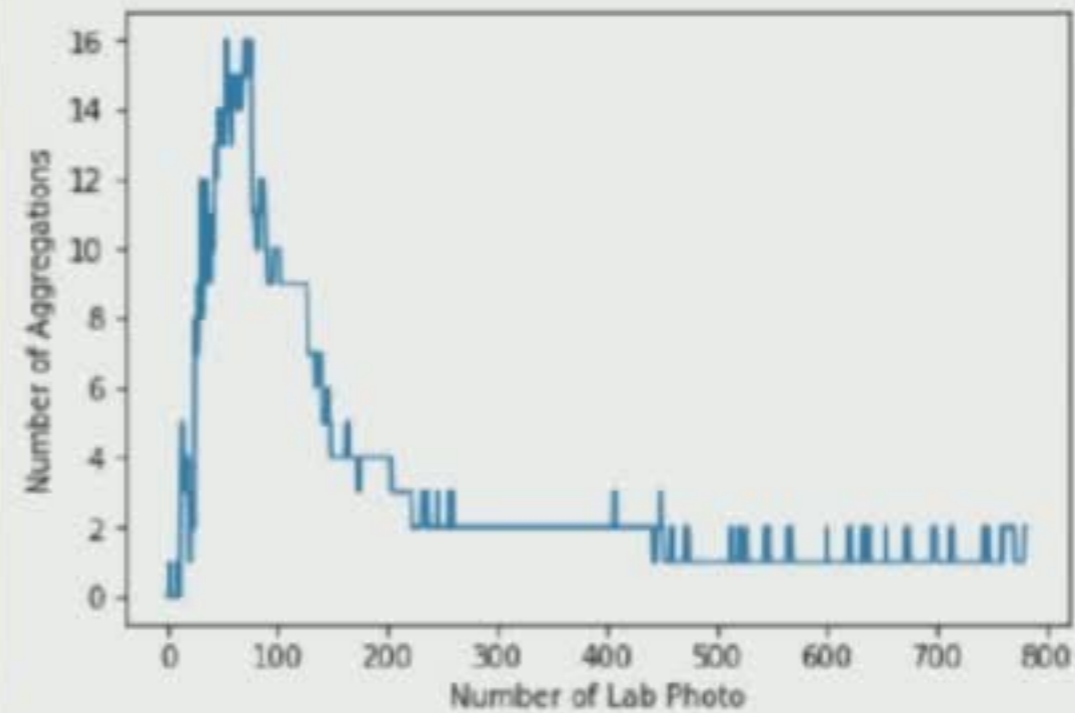
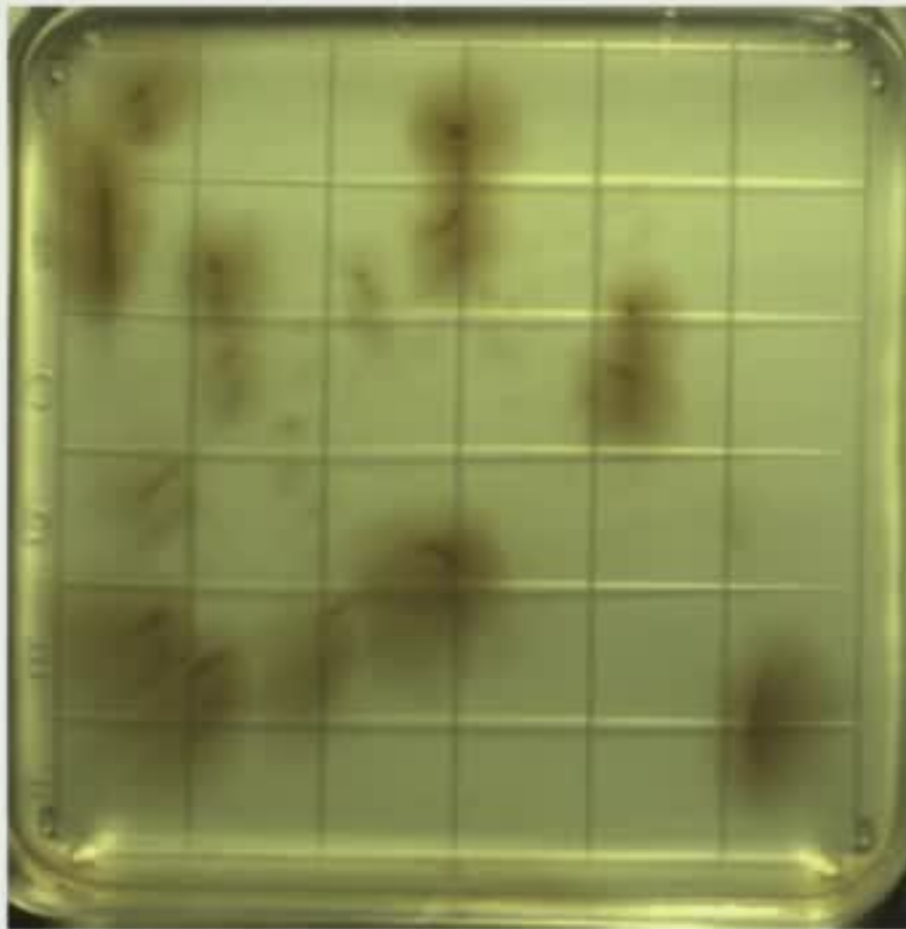


# Computational Experiment: Switch

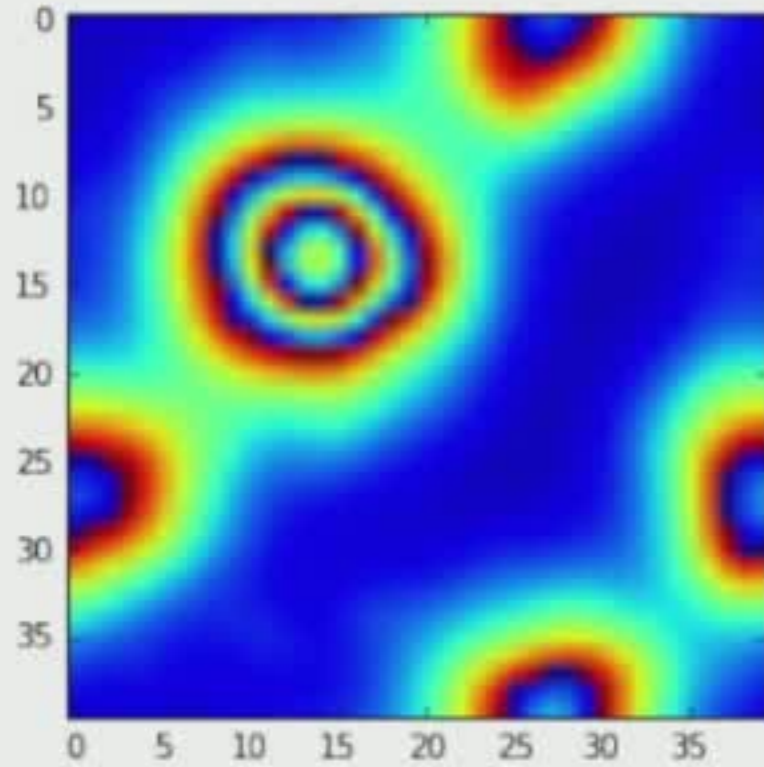
# Computational Experiment: Switch



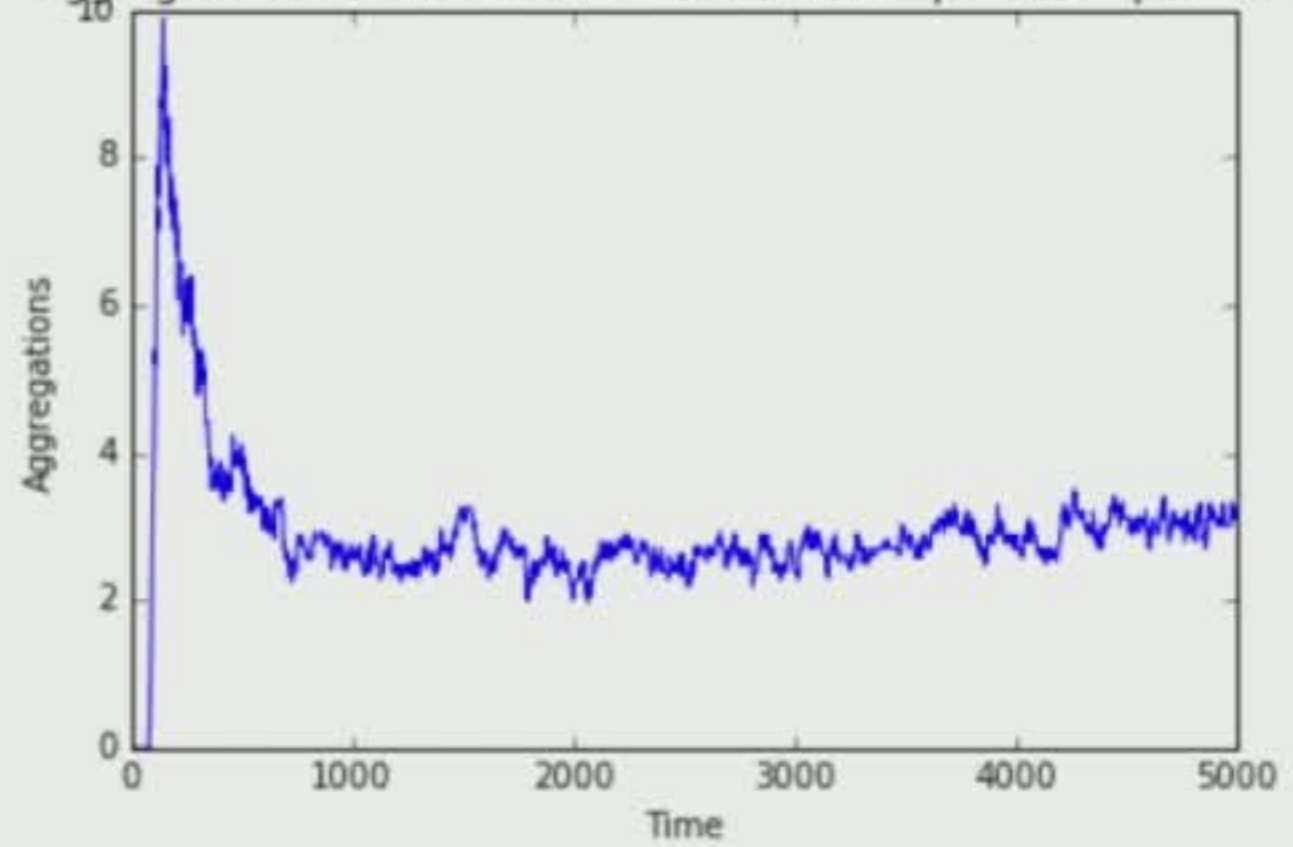
# Observed Aggregation Count



# Example of Aggregation Count



Aggregations for Normal Parameters: Ten Repeated Experiments



# Steady States

$$c_t = d_1 c_{xx} - d_2 c + f(c)\rho$$

↓ Constant Solution ↓

$$d_2 \bar{c} = f(\bar{c})\bar{\rho}$$

Perturbations:

▶ Density:  $\rho = \bar{\rho}(1 + \epsilon a)$

▶ Chemical:  $c = \bar{c}(1 + \epsilon b)$

where  $a, b$  are functions.

Characteristic Equation ( $n$  is the wave number):

$$r^3 + [d_1 n^2 - d_3 + 1] r^2 + [(d_1 + 1)n^2 - d_3] r + n^2 \left( d_1 n^2 - d_3 - \frac{\bar{c} d_2}{\delta} \right) = 0$$

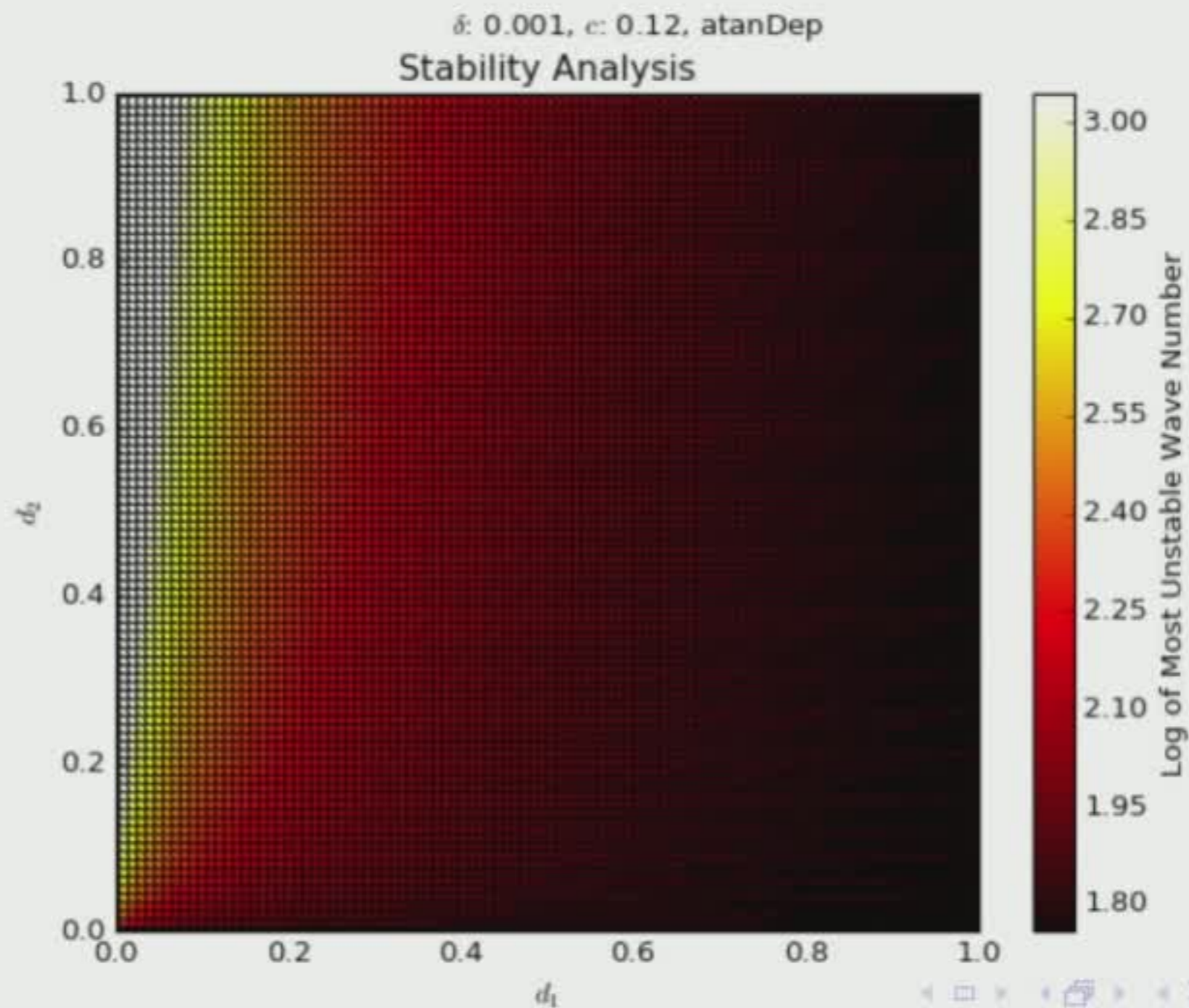
where  $d_3 = \bar{\rho} f'(\bar{c}) - d_2$

▶  $\text{Re}(r) > 0 \implies$  Instability

▶  $\text{Re}(r) < 0 \implies$  Stability

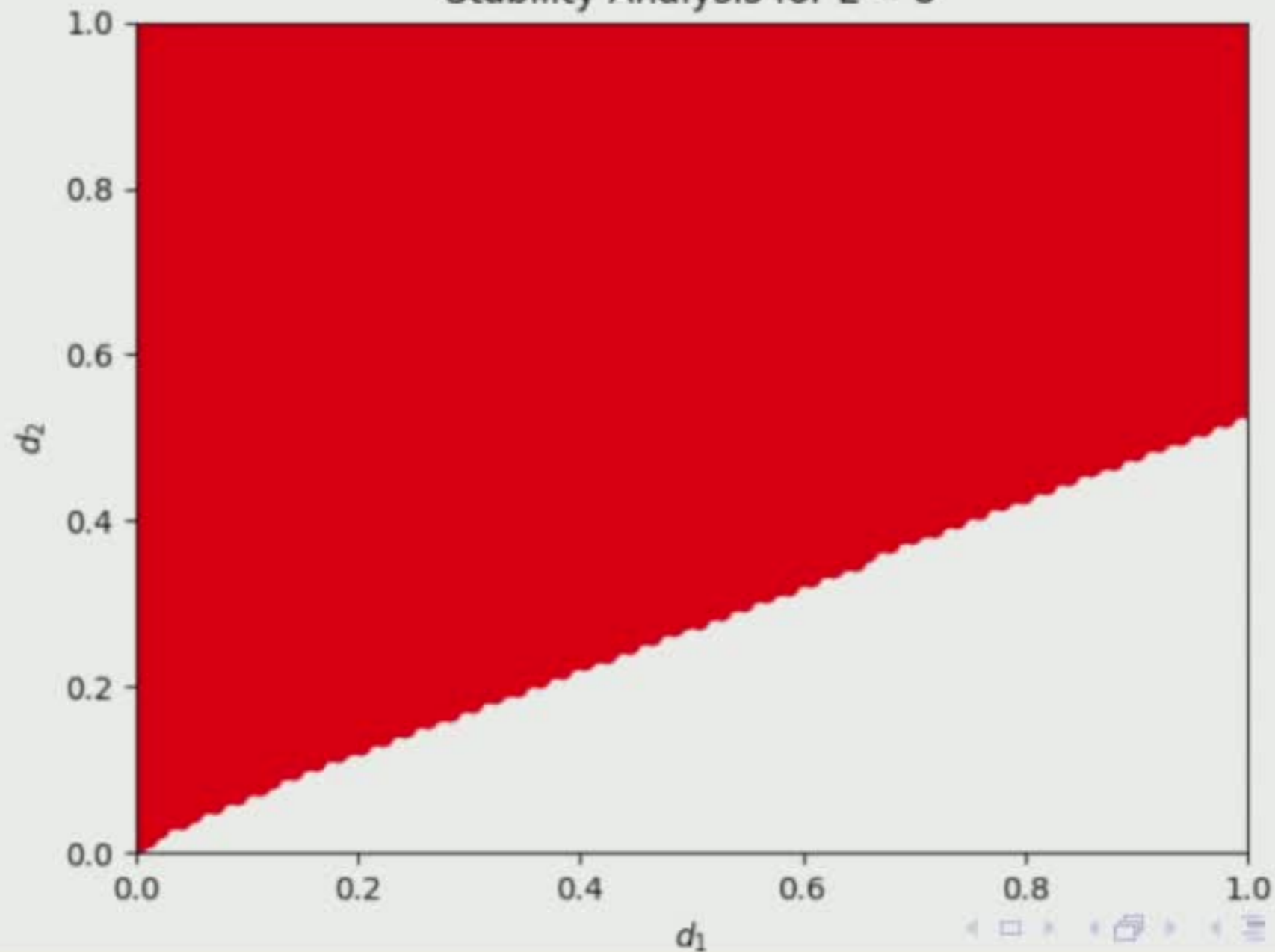


# Most Unstable Wave Number



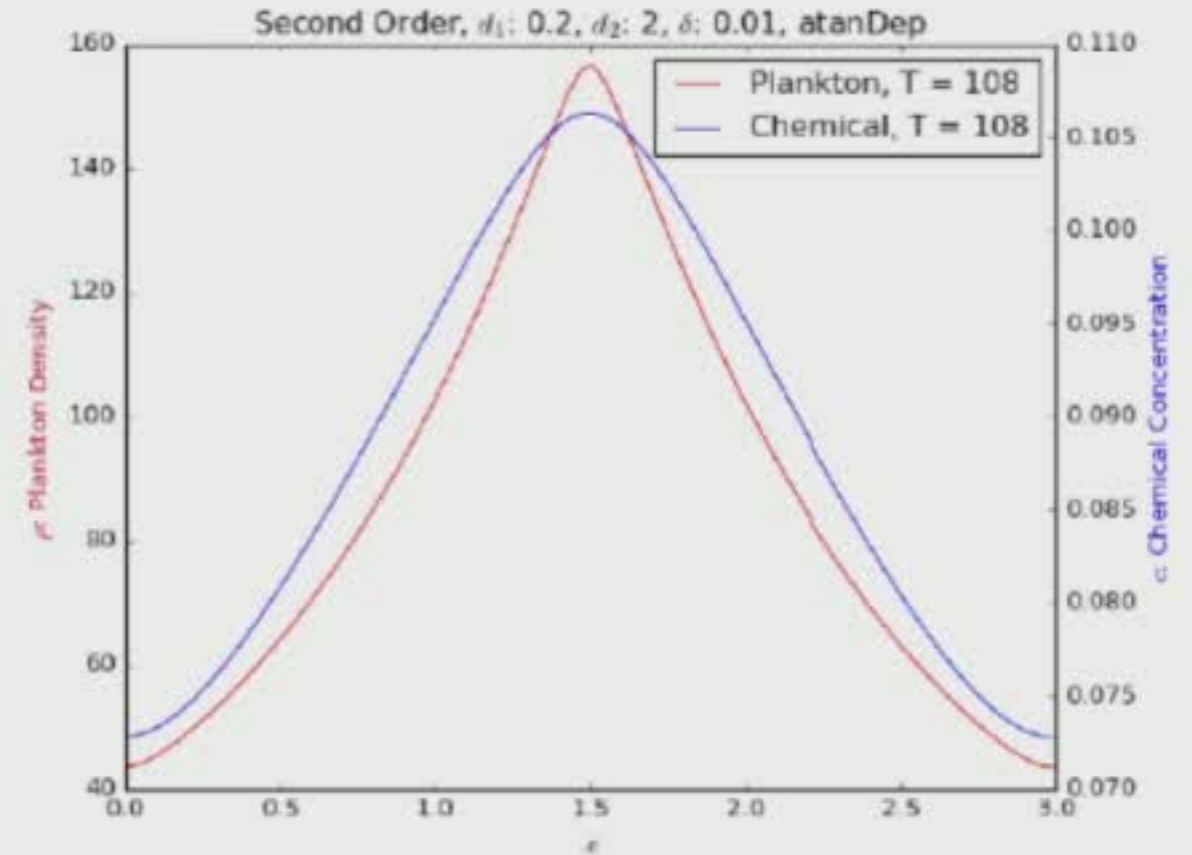
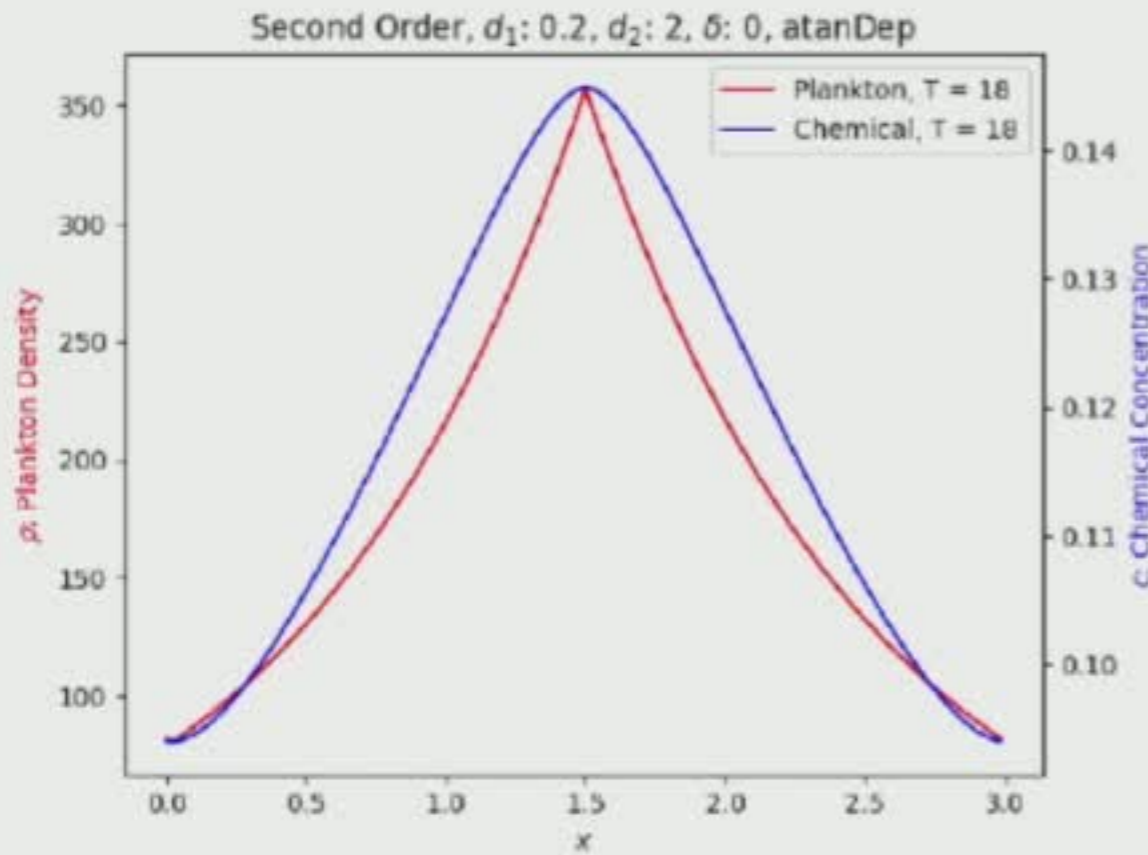
# Stability Regions

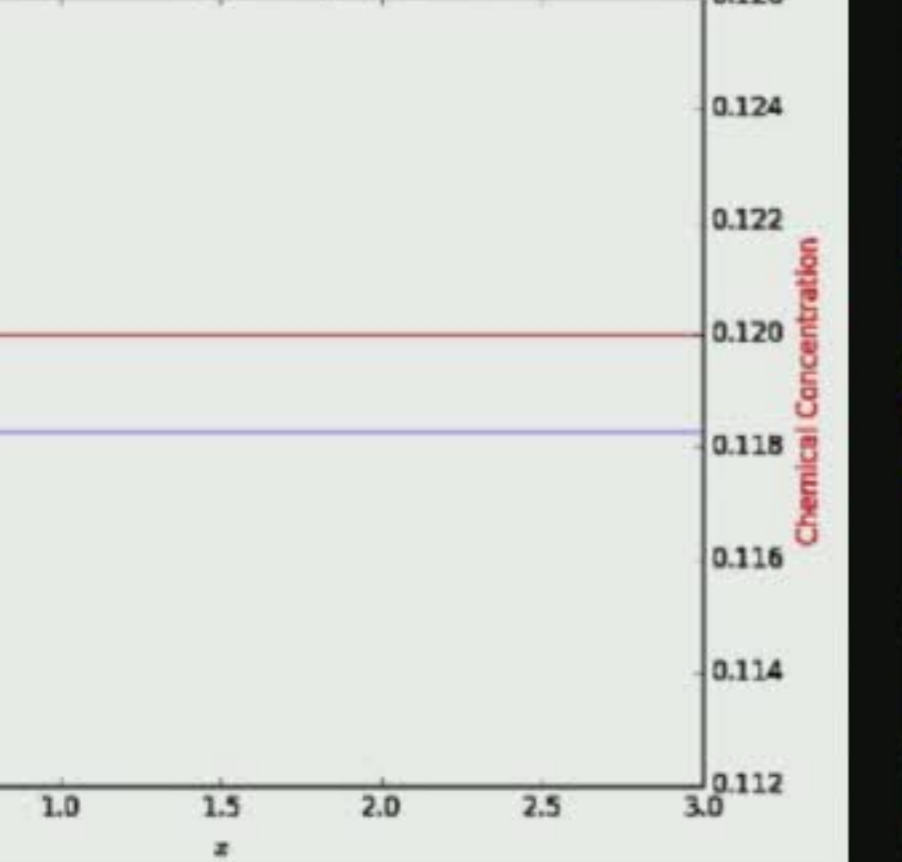
$\delta: 0.01, c: 0.12, \text{atanDep}$   
Stability Analysis for  $L = 8$



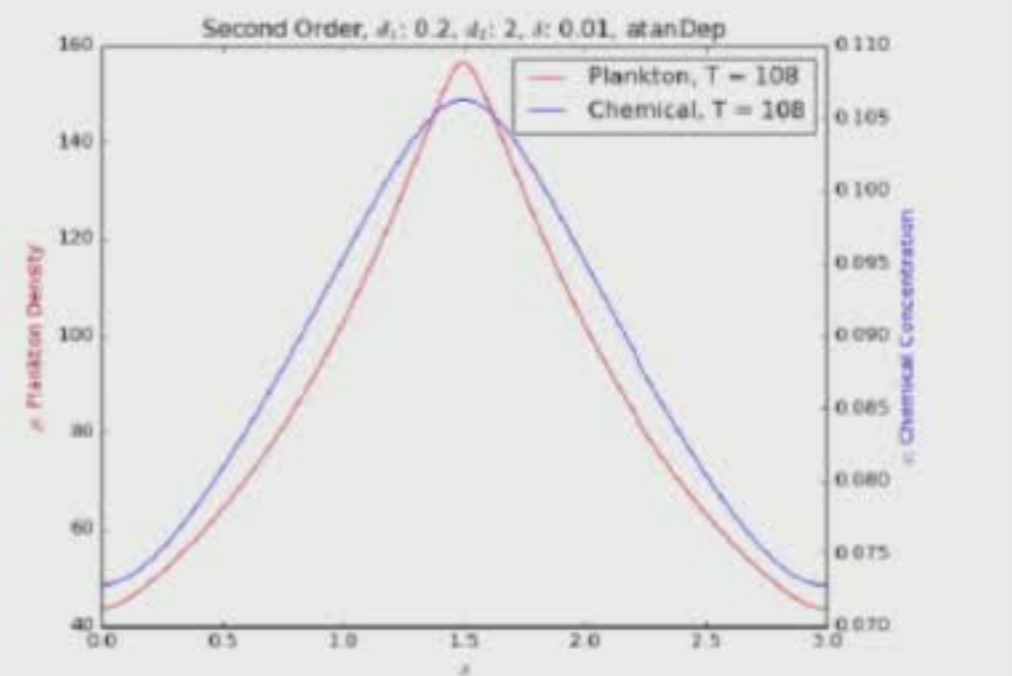
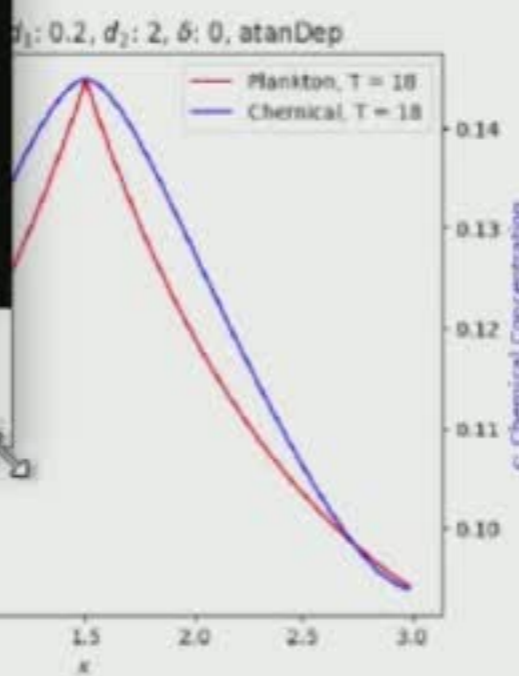
Steady States

# Steady States for Different Delta



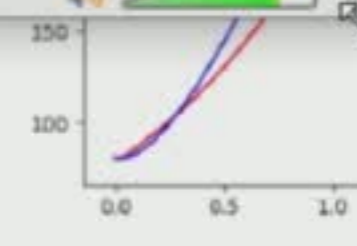


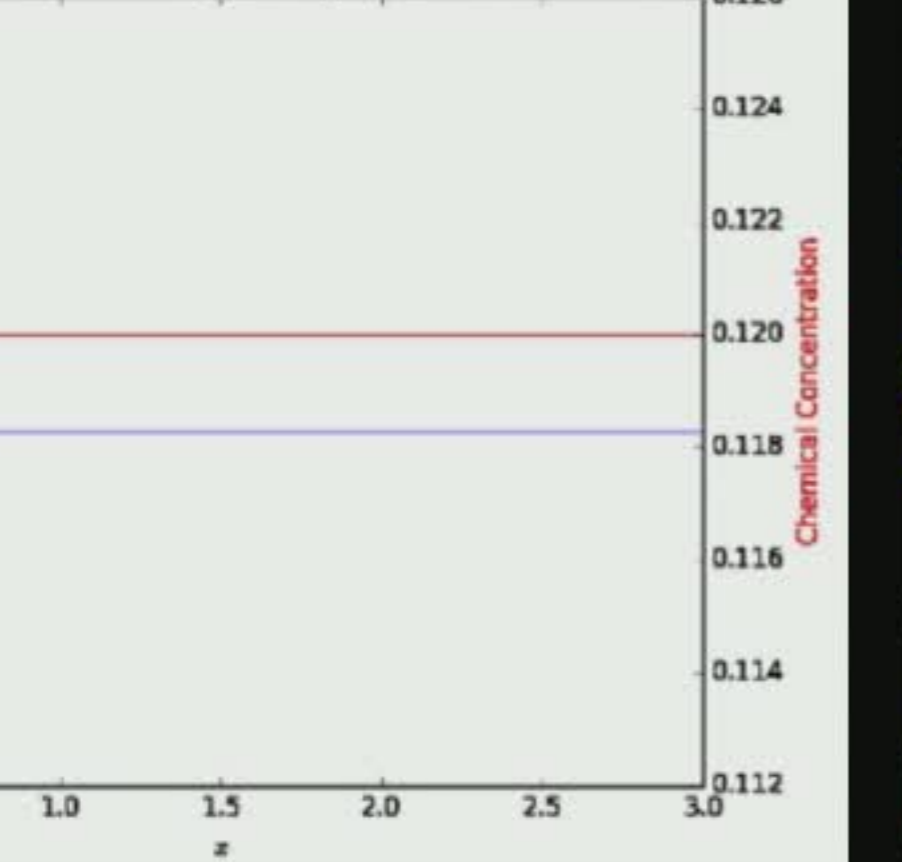
# for Different Delta



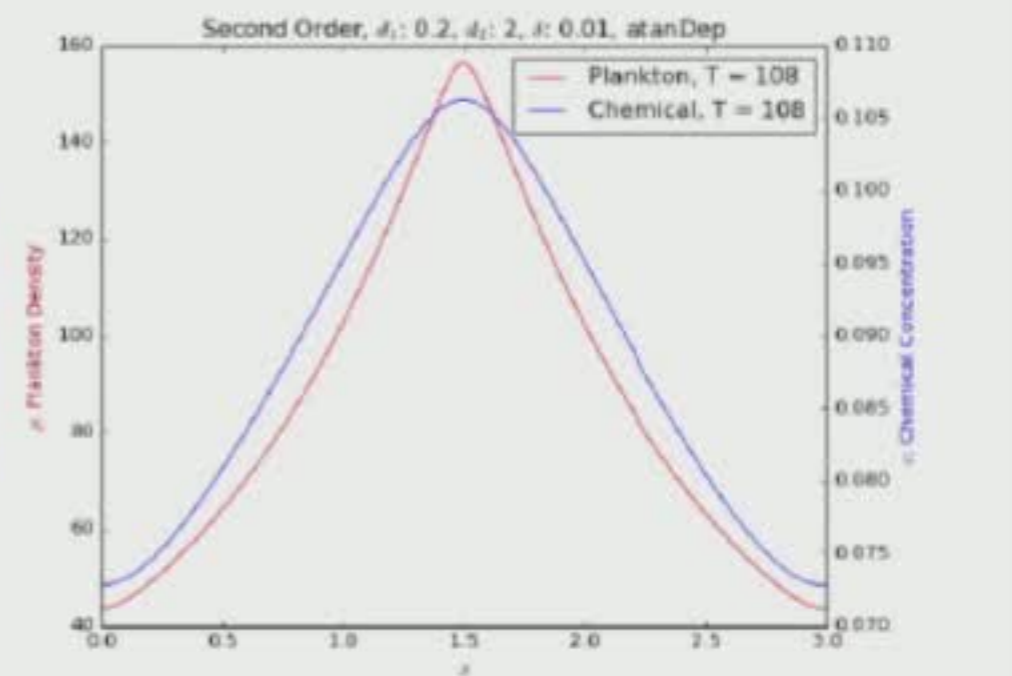
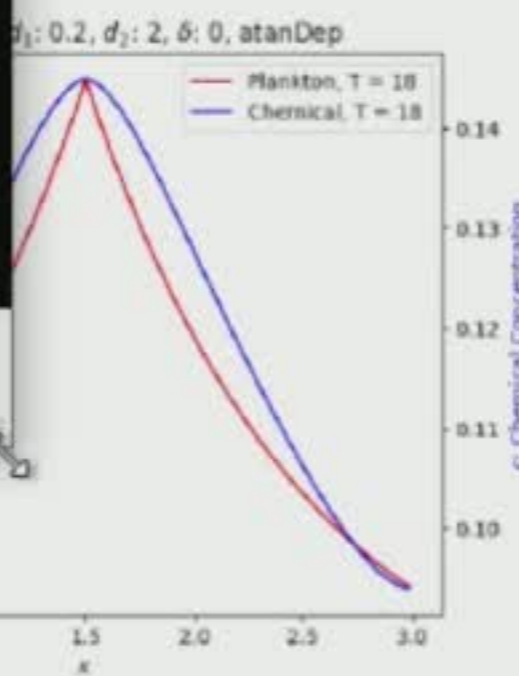
00:13

100%

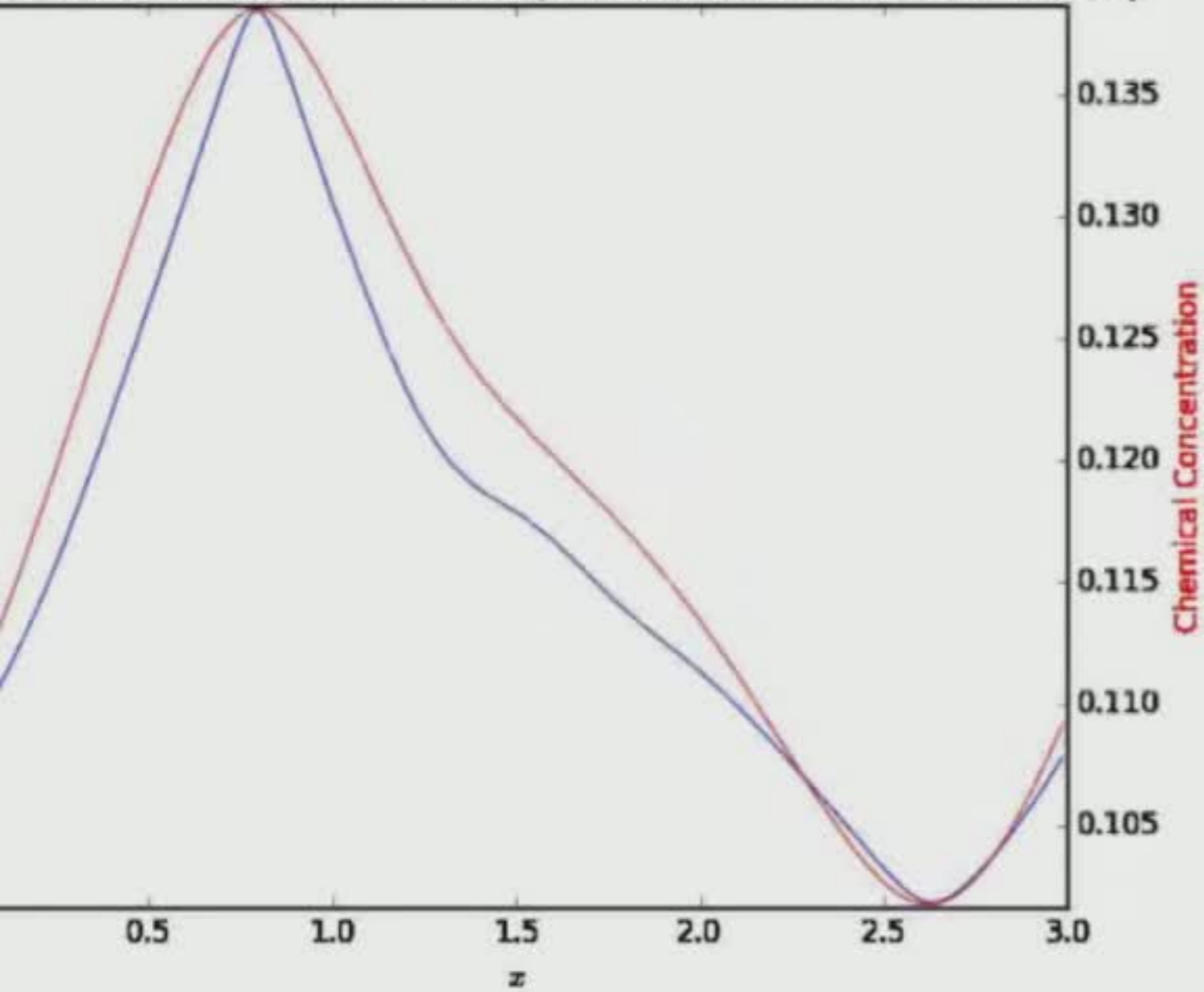




# for Different Delta



on/Chemical, Time = 26.866,  $d_1: 0.2$ ,  $d_2: 2$ ,  $N: 217$ , Func: atanDep



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Working status...

Working status...

Working status...

Working status...

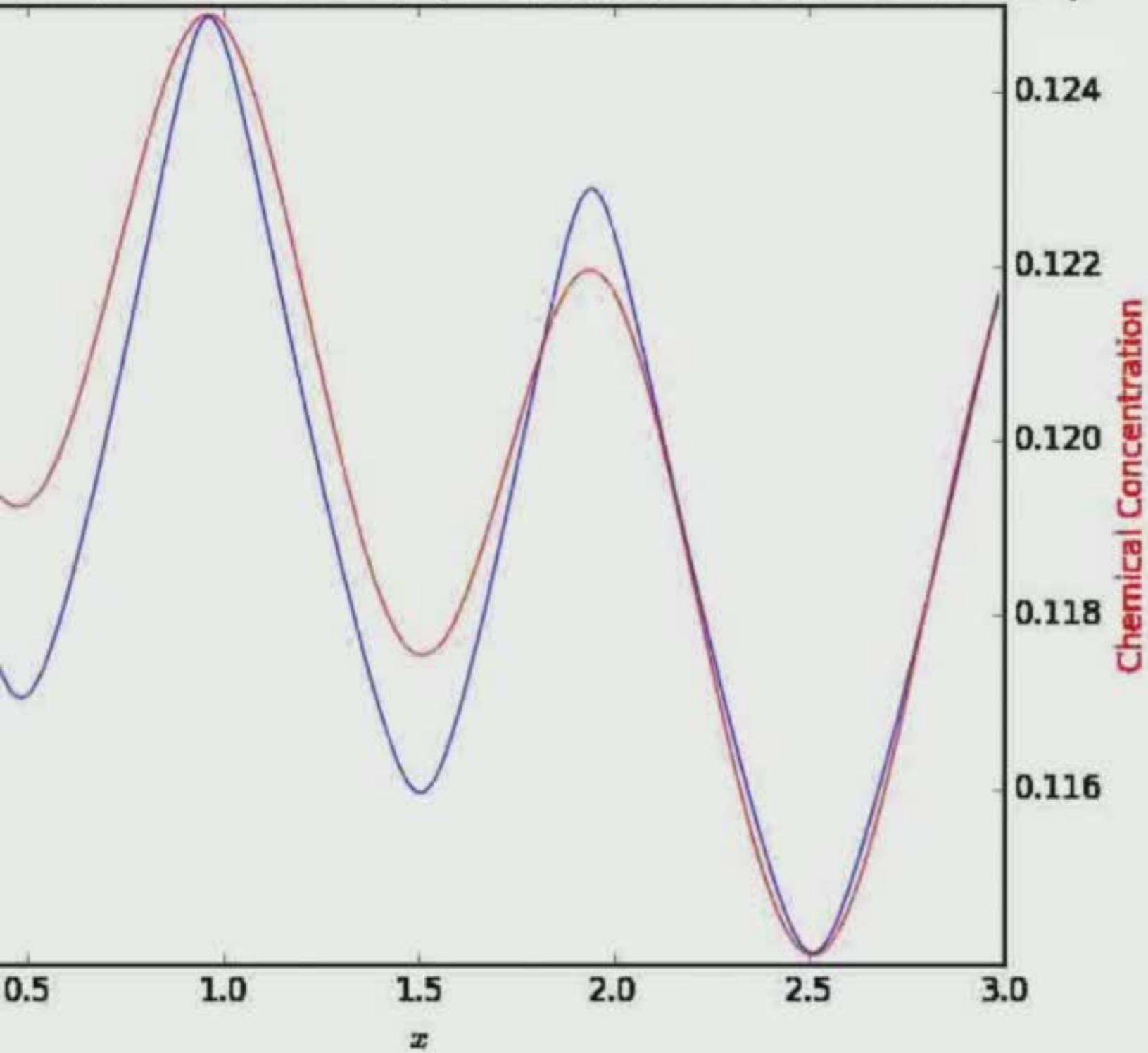
00:13

100%

Russell

Heterosigma Akashiwo

Chemical, Time = 25.156,  $d_1$ : 0.2,  $d_2$ : 2,  $N$ : 217, Func: atanDep



00:13

100%

Heterosigma Akashiwo

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Checking status...

Checking status...

Checking status...

Checking status...