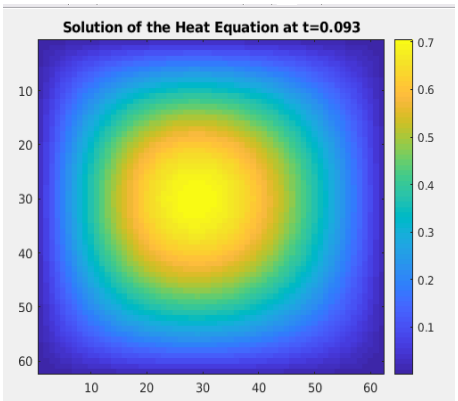
Solving Differential Equations with MATLAB

Seminar Description: This seminar will be an introduction to numerical methods used to solve differential equations. We will focus on implementing numerical methods in MATLAB (or using built-in commands), and visualizing solutions to initial-value problems. Our goal is to cover the most commonly used numerical methods and understand the advantages and disadvantages of each method.



Prerequisites: MAT 22B, basic MATLAB knowledge.

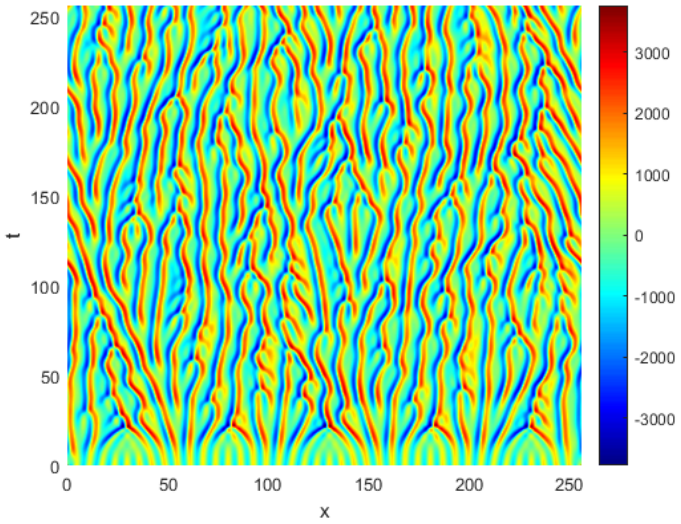
Format: We will meet weekly for one hour to review a new numerical method. Each meeting will be split into roughly 40% lecture and 50% group coding for the method of the day, with some time dedicated to showing cool visualizations of solutions from the previous week's method.

Learning Objectives: Students will learn about a variety of differential equations, the numerical methods typically used for each type of problem, and will be able to implement these numerical methods in MATLAB to solve equations. Students will gain some intuition on when to use specific numerical methods for problems. Students will also learn some visualization techniques for plotting solutions in MATLAB, with an emphasis on aesthetics.

Outline

Meeting #1: Review basic theory of differential equations

- Introductions / background
- Quick review of ODEs from 22B
- MATLAB installation / setup



Meeting #2: Forward Euler / Explicit Methods

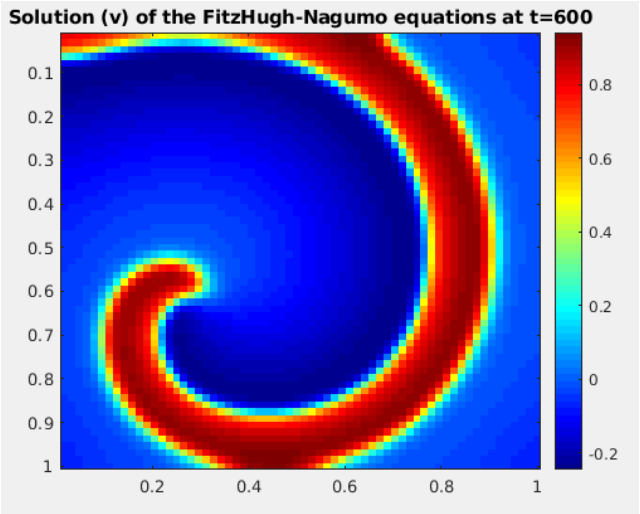
- Lecture: Forward Euler method
- Group MATLAB coding

Meeting #3: Backward Euler / Implicit Methods

- Lecture: Backward Euler
- Group MATLAB coding

Meeting #4: Runga-Kutta Methods

- Lecture: Runga-Kutta Methods
- Using ode45 in MATLAB (Group coding)



Meeting #5/6: Finite Difference Methods for Poisson Equation

- Lecture: Finite difference approximations
- Solving linear systems in MATLAB
- Sparse matrices in MATLAB

Meeting #7/8: Crank-Nicolson for the Heat Equation

- Lecture: Heat Equation: Forward Euler vs Trapezoidal
- Timestepping PDEs
- Running code for 1D / 2D Heat Equation
- Animating solutions

Meeting #9: Other PDE

- Topic decided on student interest. Possible topics include
    - IMEX Methods for Kuramoto-Sivashinsky equation
    - ADI Methods for FitzHugh-Nagumo model