Simple reaction-diffusion model

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2nd May 2019

1 Abstract

To understand Non-linear diffusion equations. Heat equations are special case of Diffusion equations. To understand the Numerical solutions of heat equations finite difference method (Forward Euler, Backward Euler and Crank Nicholson.)

2 Introduction

The diffusion equation is a partial differential equation. In physics, it describes the behavior of the collective motion of micro-particles in a material resulting from the random movement of each micro-particle. In mathematics, it is applicable in common to a subject relevant to the Markov process as well as in various other fields, such as the materials sciences, information science, life science, social science, and so on. These subjects described by the diffusion equation are generally called Brown problems.

In physics and mathematics, the heat equation is a partial differential equation that describes how the distribution of some quantity (such as heat) evolves over time in a solid medium, as it spontaneously flows from places where it is higher towards places where it is lower. It is a special case of the diffusion equation.

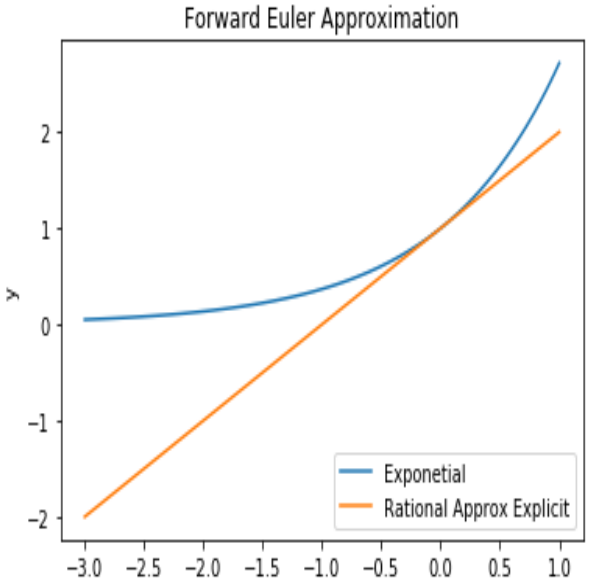
Reaction-diffusion (RD) equations arise naturally in systems consisting of many interacting components, (e.g., chemical reactions) and are widely used to describe pattern-formation phenomena in variety of biological, chemical and physical systems.

3 Methods

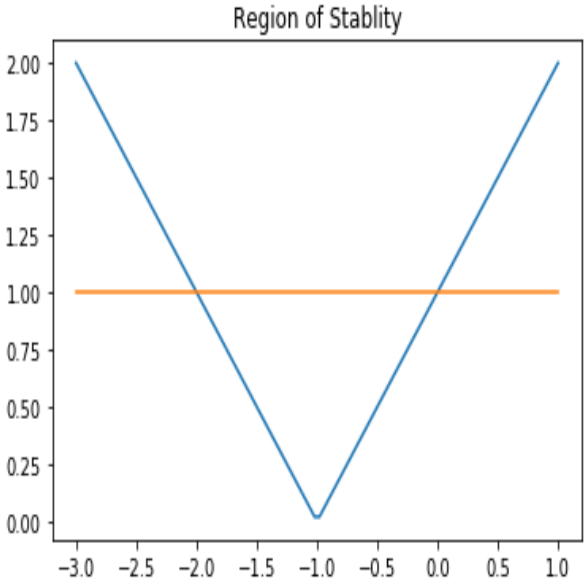
The mathematical methods used are Euler Methods and Crank Nicholson Scheme. Different python libraries like numpy and matplotlib etc were used.

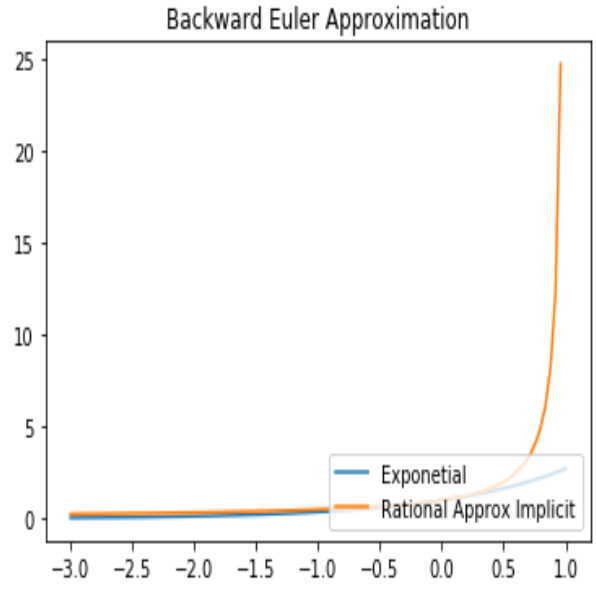
4 Results and Conclusions

4.1 GRAPHICAL RATIONAL APPROXIMATION

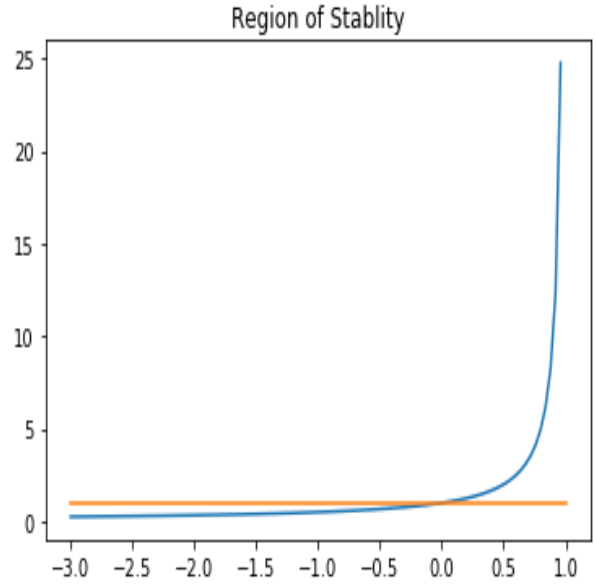
- 

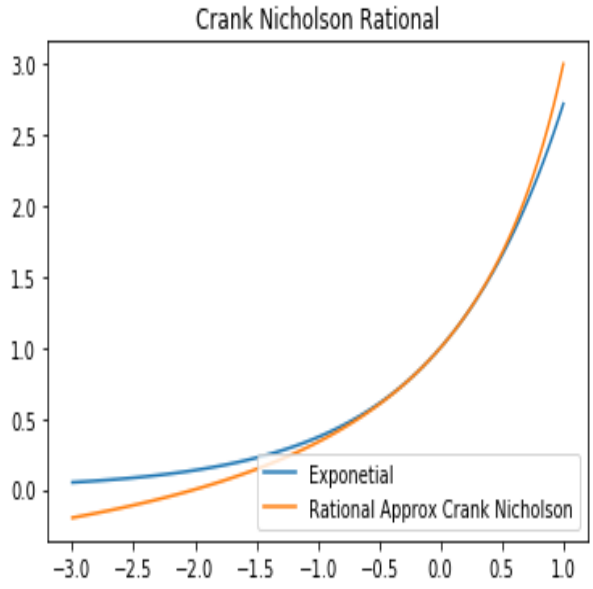
The stablity region is between $-2 < y < 0$, this can lead to unstablity of the method.

- 

- 

The stablity region is between $y < 0$, this can lead to stablity of the method.

- 

- 

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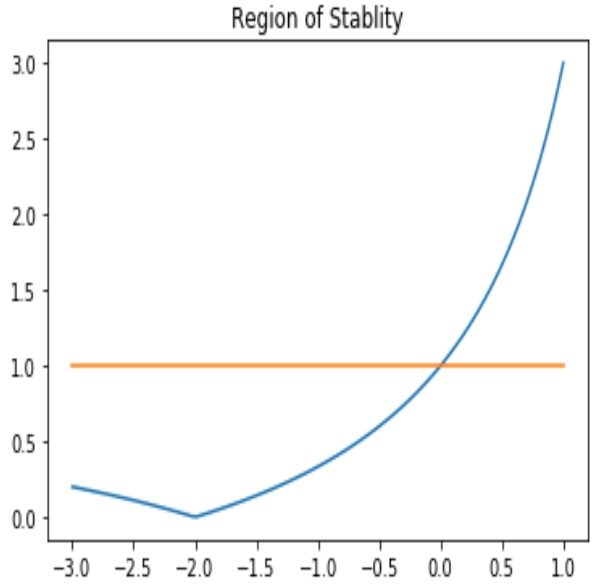
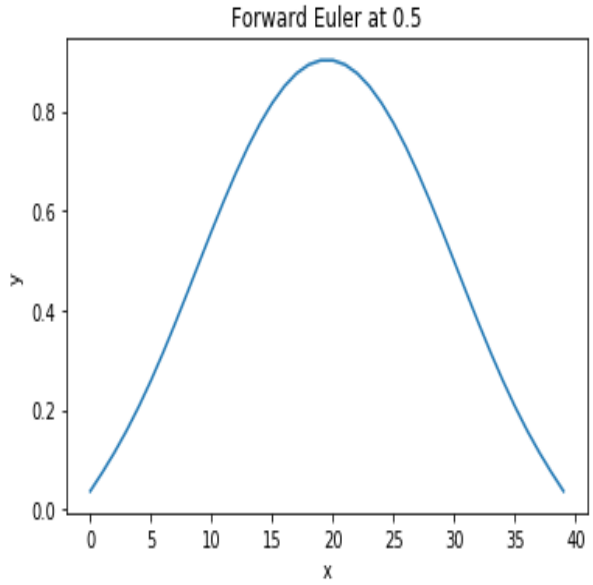
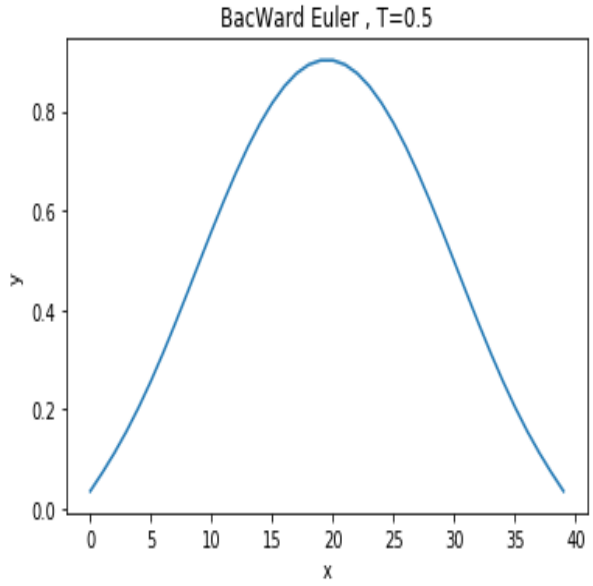
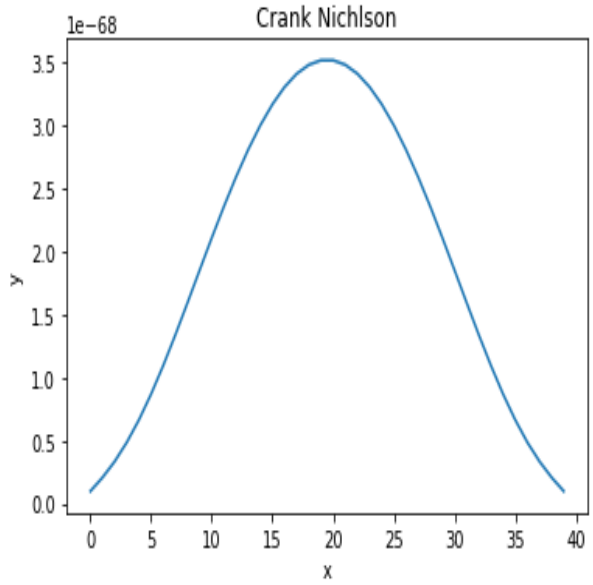
- 

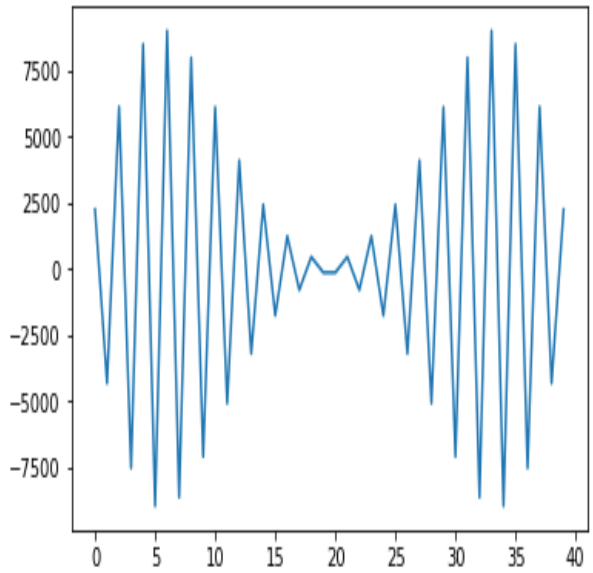
4.2 TIME STEPPING SCHEMES

- 

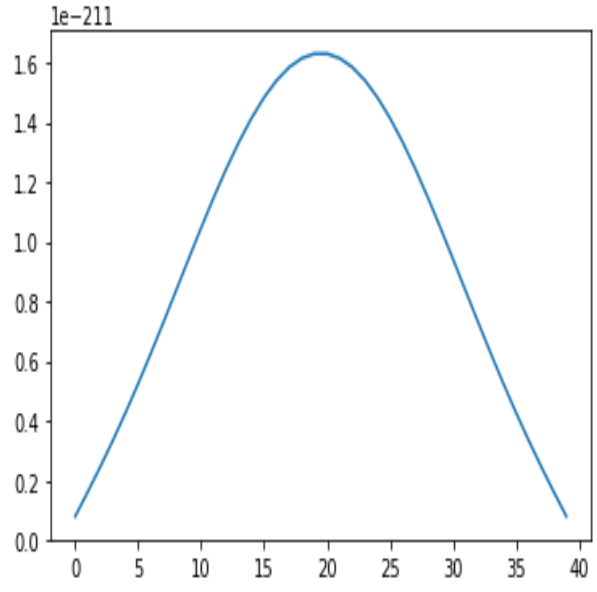
- 

- 

4.3 VIOLATION OF TIME STEPPING SCHEMES

- 

Explicit Method not stable

- 

Crank Nicholson Scheme
Stable for tau $< h^2/2$

5 References

- En.wikipedia.org. (2018). Matrix exponential. [online] Available at: https://en.wikipedia.org/wiki/Matrixexponential[Accessed14M ay2018].
- Math.la.asu.edu. (2018). [online] Available at: https://math.la.asu.edu/dajones/class/275/ch2.pdf [Accessed 14 May 2018].
- https://en.wikipedia.org/wiki/Diffusion$_e quationhttps : //www.uni-muenster.de/imperia/md/content/$ 2017/$num_m ethods_i/rd.pdf$

- Partial Code help from Zain Salman Dar