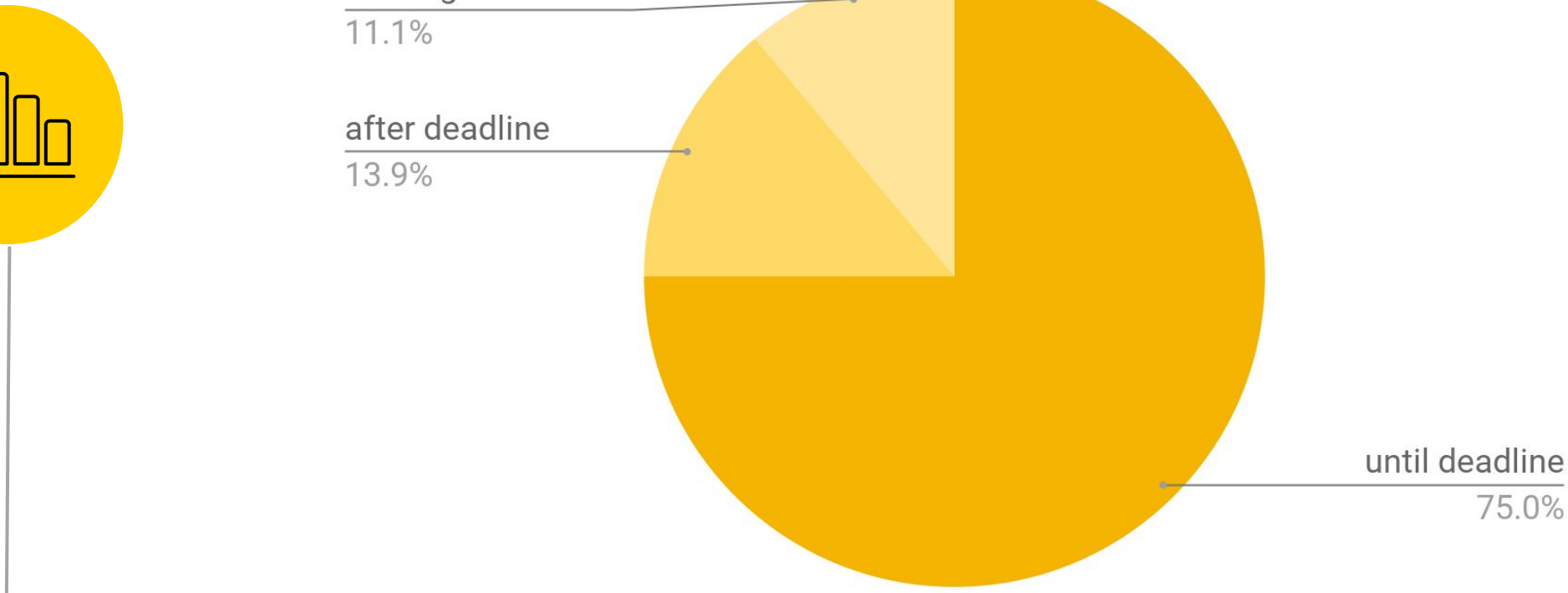
Project 1

Exceptional solutions, common mistakes

Technicalities



Technicalities

What makes us...

 HAPPY

- Informative filenames
- Only one PDF file in folder
- Clear indication of which files to correct

Please, name your next assignment **Project2.pdf** and **do not put it into a subdirectory**!

Technicalities

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SAD

- Sending in your assignments late

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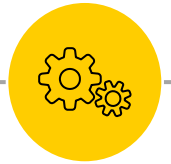

Technicalities

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 SAD

- Sending in your assignments late

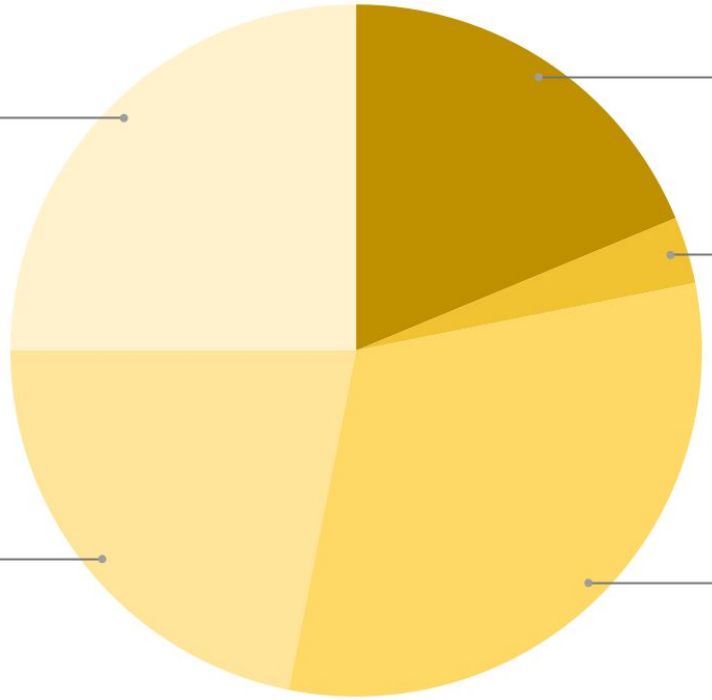
 MAD

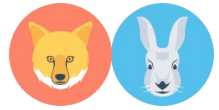
- Not sending in your assignment at all
- Not sending PDF files
- **Sending files via e-mail**

Use Kooplex-edu!
If you encounter problems, ASK FOR HELP!

Topics

Other
21.9%





Population dynamics
18.8%

Quantum mechanics
3.1%

Planetary motion
31.3%

Topics

What makes us...

 HAPPY

- **Unique, creative, current** topics
- Anything you're **passionate** about
- Anything you think is **important**
- Something you would like everyone to know about
- Something you would like to **learn**

Topics

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▸ Simulation of the beam loss of BES diagnostics

I chose this topic because I work on BES signals during my research.

Beam emission spectroscopy (BES) is one of the diagnostics on fusion devices. The main idea of the BES is that an accelerated neutral beam is injected into the plasma. As the beam penetrates the plasma, the atoms of the beam interact with the particles of the plasma. The alkali atoms either get excited then deexcited, or ionized. During deexcitation the atoms radiate characteristic photons, which we measure. Since the number of collision is proportional to the local density of the electrons in the plasma, the local measured intensity of the emitted light should be proportional to the local electron density. However, the collision is proportional to the local density of the beam too, which is decreasing when we go into the plasma because of the ionization. It complicates the problem, but makes the simulation more exciting.

Lili Édes

Topics

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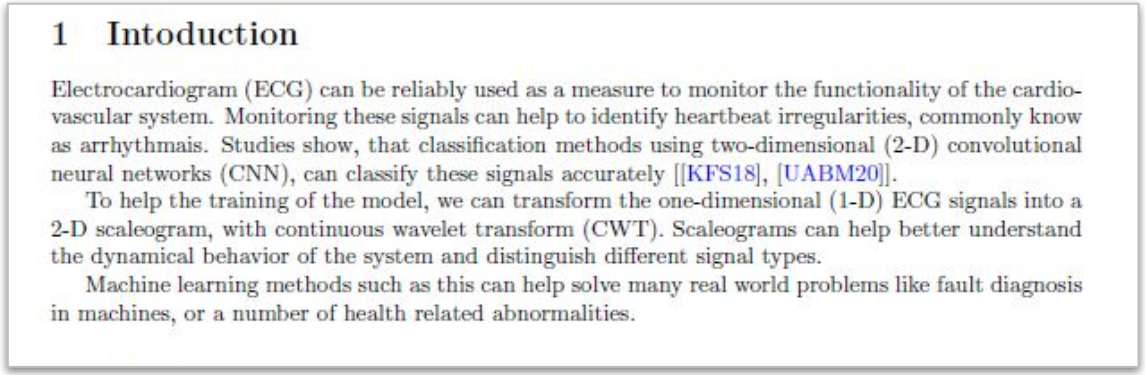
▸ Detecting Arrythmia with Wavelet Transformation and Convolutional Neural Networks



1 Intoduction

Electrocardiogram (ECG) can be reliably used as a measure to monitor the functionality of the cardio-vascular system. Monitoring these signals can help to identify heartbeat irregularities, commonly know as arrhythmais. Studies show, that classification methods using two-dimensional (2-D) convolutional neural networks (CNN), can classify these signals accurately [[KFS18], [UABM20]].

To help the training of the model, we can transform the one-dimensional (1-D) ECG signals into a 2-D scaleogram, with continuous wavelet transform (CWT). Scaleograms can help better understand the dynamical behavior of the system and distinguish different signal types.

Machine learning methods such as this can help solve many real world problems like fault diagnosis in machines, or a number of health related abnormalities.

Bence Dajka

Topics

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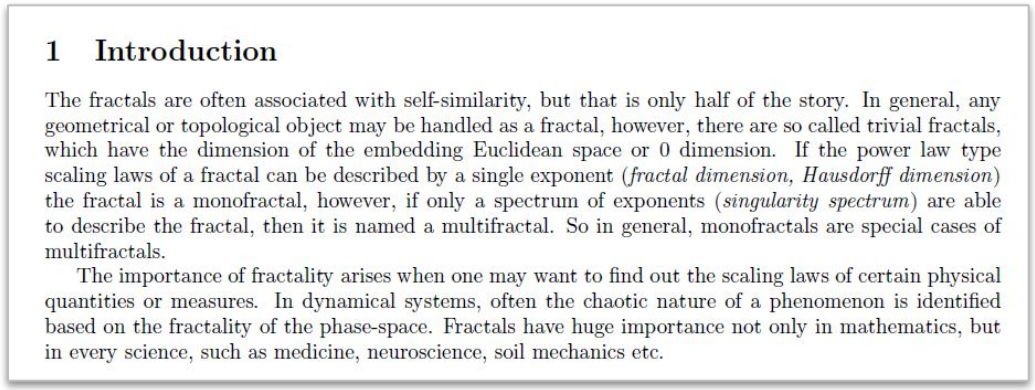
▸ Multifractal spectra



1 Introduction

The fractals are often associated with self-similarity, but that is only half of the story. In general, any geometrical or topological object may be handled as a fractal, however, there are so called trivial fractals, which have the dimension of the embedding Euclidean space or 0 dimension. If the power law type scaling laws of a fractal can be described by a single exponent (*fractal dimension, Hausdorff dimension*) the fractal is a monofractal, however, if only a spectrum of exponents (*singularity spectrum*) are able to describe the fractal, then it is named a multifractal. So in general, monofractals are special cases of multifractals.

The importance of fractality arises when one may want to find out the scaling laws of certain physical quantities or measures. In dynamical systems, often the chaotic nature of a phenomenon is identified based on the fractality of the phase-space. Fractals have huge importance not only in mathematics, but in every science, such as medicine, neuroscience, soil mechanics etc.

Sándor Lipcsei

Topics

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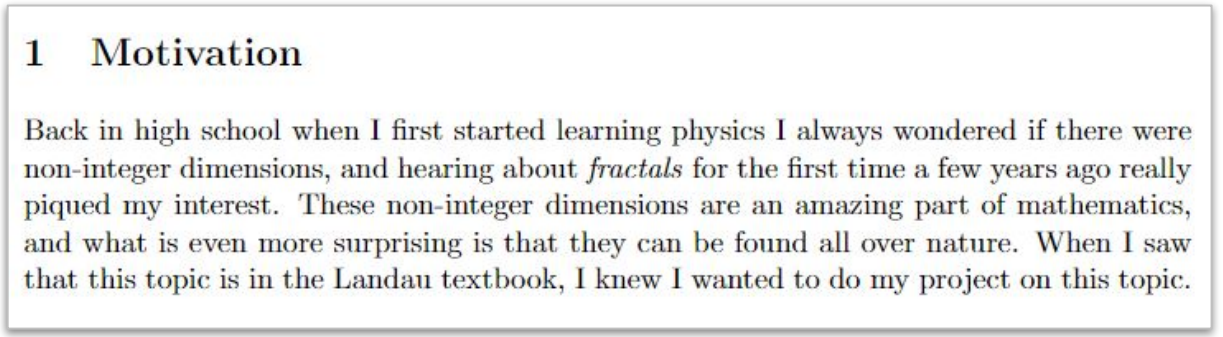
▸ An algorithm to estimate the Hausdorff dimension of country borders



1 Motivation

Back in high school when I first started learning physics I always wondered if there were non-integer dimensions, and hearing about *fractals* for the first time a few years ago really piqued my interest. These non-integer dimensions are an amazing part of mathematics, and what is even more surprising is that they can be found all over nature. When I saw that this topic is in the Landau textbook, I knew I wanted to do my project on this topic.

Martin Gyügyi

Topics

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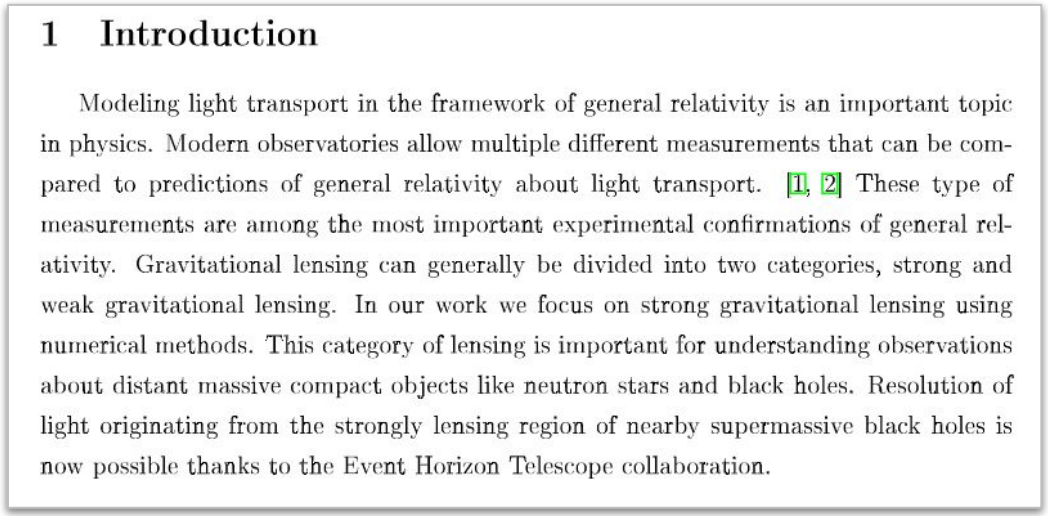
▸ General relativistic ray tracing



1 Introduction

Modeling light transport in the framework of general relativity is an important topic in physics. Modern observatories allow multiple different measurements that can be compared to predictions of general relativity about light transport. [1, 2] These type of measurements are among the most important experimental confirmations of general relativity. Gravitational lensing can generally be divided into two categories, strong and weak gravitational lensing. In our work we focus on strong gravitational lensing using numerical methods. This category of lensing is important for understanding observations about distant massive compact objects like neutron stars and black holes. Resolution of light originating from the strongly lensing region of nearby supermassive black holes is now possible thanks to the Event Horizon Telescope collaboration.

Zoltán Kürti

Topics

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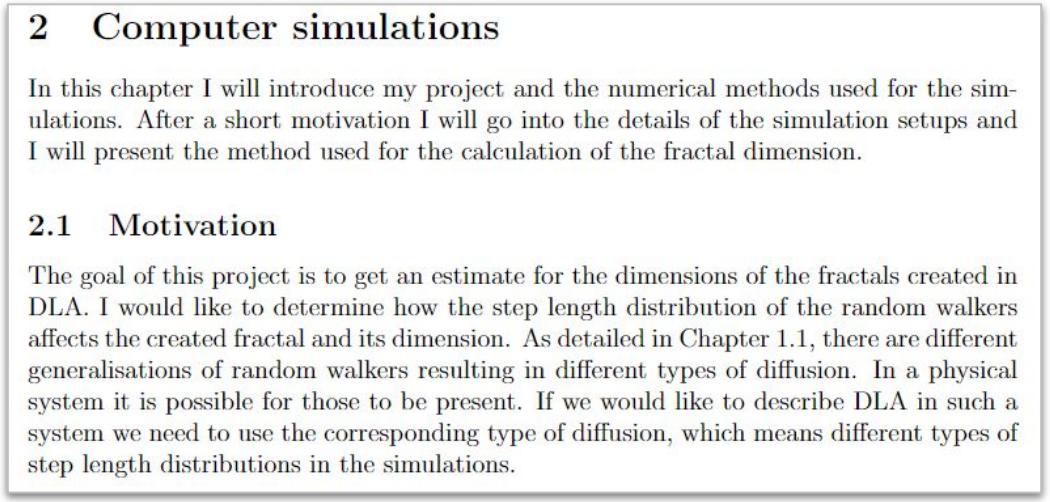
▸ Diffusion-Limited Aggregation



2 Computer simulations

In this chapter I will introduce my project and the numerical methods used for the simulations. After a short motivation I will go into the details of the simulation setups and I will present the method used for the calculation of the fractal dimension.

2.1 Motivation

The goal of this project is to get an estimate for the dimensions of the fractals created in DLA. I would like to determine how the step length distribution of the random walkers affects the created fractal and its dimension. As detailed in Chapter 1.1, there are different generalisations of random walkers resulting in different types of diffusion. In a physical system it is possible for those to be present. If we would like to describe DLA in such a system we need to use the corresponding type of diffusion, which means different types of step length distributions in the simulations.

Balázs Kórodi

Topics

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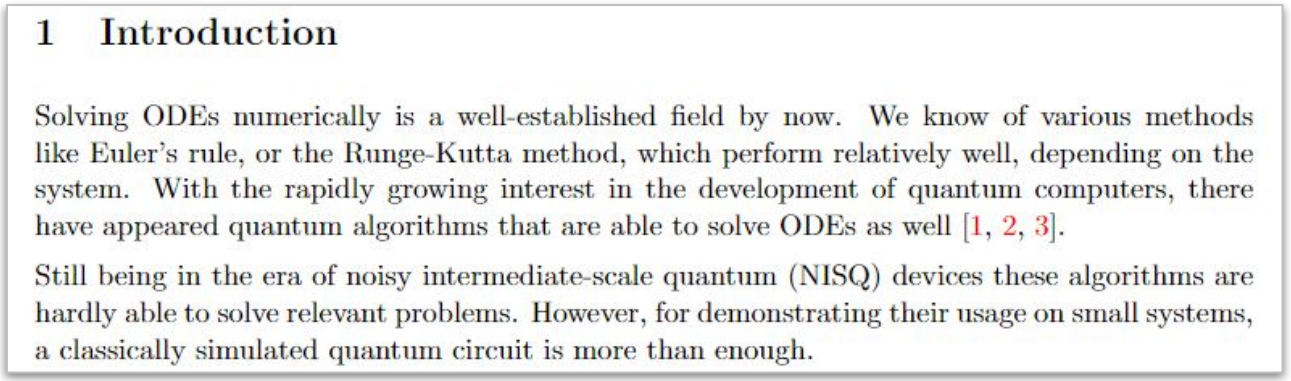
▸ Solving Ordinary Differential Equations on a Quantum Computer



1 Introduction

Solving ODEs numerically is a well-established field by now. We know of various methods like Euler's rule, or the Runge-Kutta method, which perform relatively well, depending on the system. With the rapidly growing interest in the development of quantum computers, there have appeared quantum algorithms that are able to solve ODEs as well [1, 2, 3].

Still being in the era of noisy intermediate-scale quantum (NISQ) devices these algorithms are hardly able to solve relevant problems. However, for demonstrating their usage on small systems, a classically simulated quantum circuit is more than enough.

Bence Bakó

Topics

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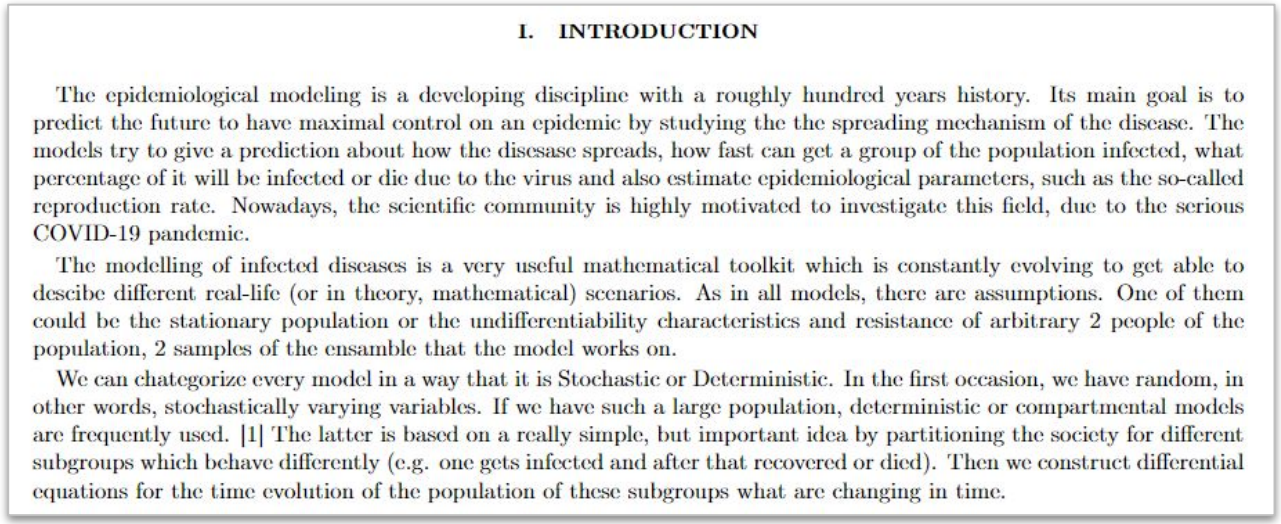
▸ The SIS model and its generalisations



I. INTRODUCTION

The epidemiological modeling is a developing discipline with a roughly hundred years history. Its main goal is to predict the future to have maximal control on an epidemic by studying the the spreading mechanism of the disease. The models try to give a prediction about how the disesase spreads, how fast can get a group of the population infected, what percentage of it will be infected or die due to the virus and also estimate epidemiological parameters, such as the so-called reproduction rate. Nowadays, the scientific community is highly motivated to investigate this field, due to the serious COVID-19 pandemic.

The modelling of infected diseases is a very useful mathematical toolkit which is constantly evolving to get able to descibe different real-life (or in theory, mathematical) scenarios. As in all models, there are assumptions. One of them could be the stationary population or the undifferentiability characteristics and resistance of arbitrary 2 people of the population, 2 samples of the ensamble that the model works on.

We can chategorize every model in a way that it is Stochastic or Deterministic. In the first occasion, we have random, in other words, stochastically varying variables. If we have such a large population, deterministic or compartmental models are frequently used. [1] The latter is based on a really simple, but important idea by partitioning the society for different subgroups which behave differently (e.g. one gets infected and after that recovered or died). Then we construct differential equations for the time evolution of the population of these subgroups what are changing in time.

Tamás Páhoki

Topics

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SAD

- Choosing an interesting topic and **not explaining** it

Topics

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- Something you would like to **learn**

SAD

- Choosing an interesting topic and **not explaining** it

MAD

- Choosing something that obviously bores you
- Not taking the effort to read about your topic
- **Copying your whole report from other sources**

Plagiarism is not tolerated in the scientific community!

Structure

What makes us...

 HAPPY

- **Motivation**, introduction
- **Clear goals**
- Theoretical background
- Results **with discussion**
- **References**
- Title page **with your name**

Structure

What makes us...

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 SAD

- Interesting topic without any exploration goals
- Mostly correct theoretical background with unexplained quantities
- Great results without discussion

Structure

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SAD

- Interesting topic without any exploration goals
- Mostly correct theoretical background with unexplained quantities
- Great results without discussion

MAD

- Unnecessary amount of irrelevant introduction
- No theoretical background
- **Incorrect formulas**

Trial & error

What makes us...

 HAPPY

- Discussing your experiences
- Explaining why it did (not) work
- Trying other methods
- Mentioning differences from the literary values
- **Quantitative comparison** with the literature

Trial & error

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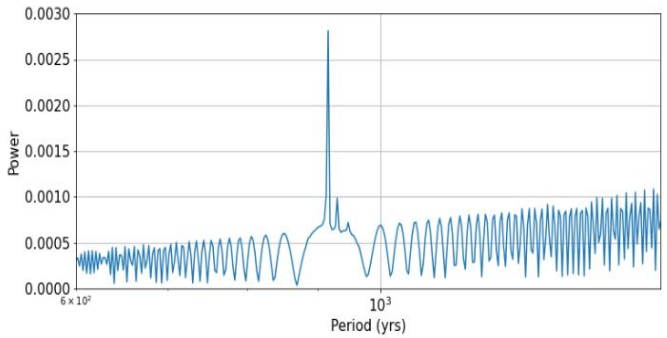

Figure 14: The Fourier-spectrum of the x-position of Jupiter, close-up around 10^3 years

This peak indeed corresponds to the famous 5:2 resonance between Jupiter and Saturn, as it is in the range of $\sim$ 100 orbits as expected from giant planets. To see this trend, we can construct a slowly varying resonant angle, corresponding to Jupiter's orbit:

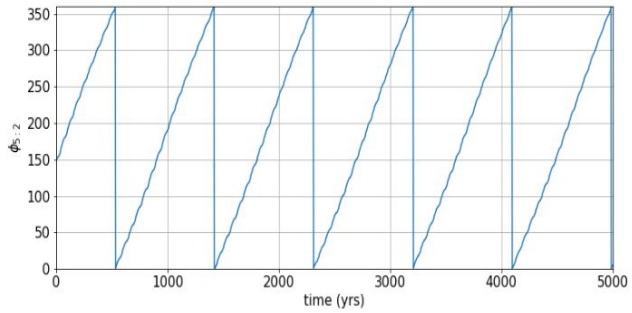

Figure 15: The circulation of the resonant $\phi_{5:2}$ angle

Indeed it circulates with a period of roughly 900 years, corresponding to the blip on Figure 14.

Máté Pszota

Trial & error

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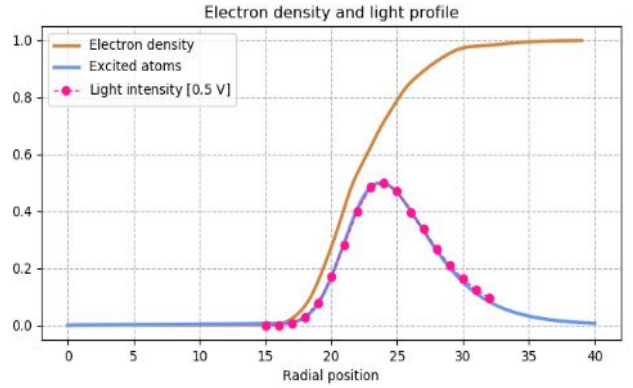

Figure 12: Agreement between simulation and measurement(pink is the measured data)

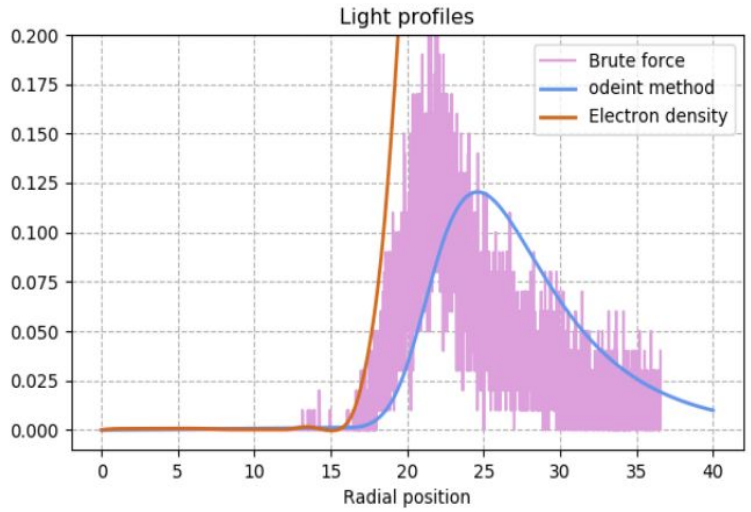

Figure 17: Solution with the brute force method

Lili Édes

Trial & error

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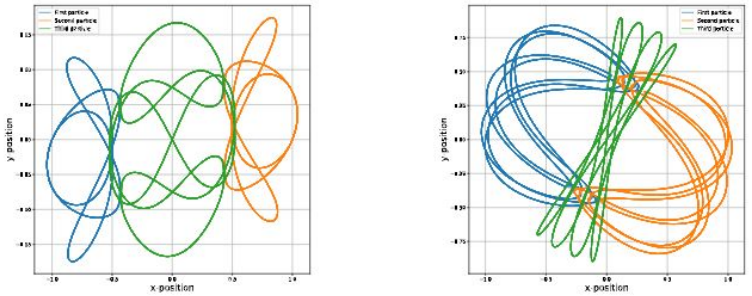
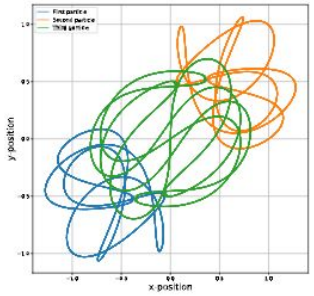
2.1 Reproduce three periodic solution, stability over the number of periods

To numerically investigate the periodic solution, I used the initial conditions in the Suvakov article [4]. I used the Python programming language and the scipy.integrate package. I worked with $G = 1$ and $m_1 = m_2 = m_3$, and the postions and velocities have no dimensions too. I chose the butterfly I., dragonfly and the yin-yang II. solutions. The initial conditions and the periods are in Table 1. I set the time limit to ten periods, because all the solutions are stable in in this time scale.



(a) Butterfly I

(b) Dragonfly



(c) Yin-yang I

Figure 2: Three periodic solution over 10 period.

György Kálvin

Trial & error

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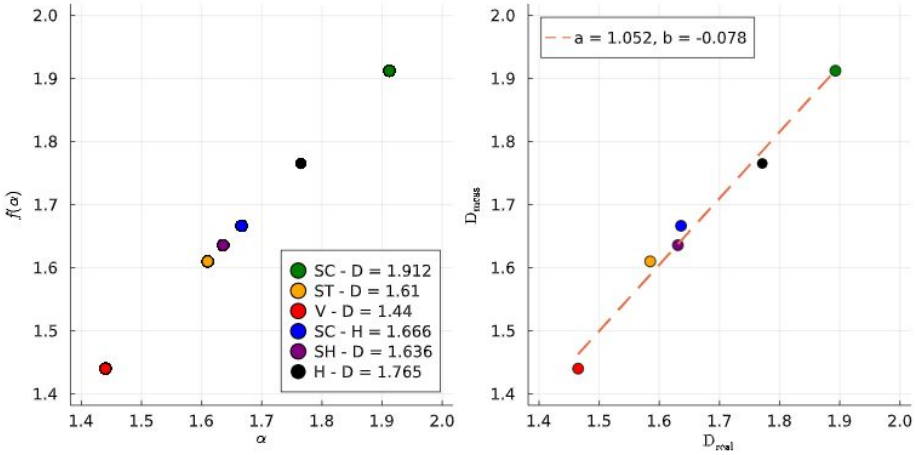

Figure 4: The obtained singularity spectras for monofractals are shown on the left image, while on the right image calibration curve of the method. The method yields a relative error of $\Delta \approx 5.2\%$;

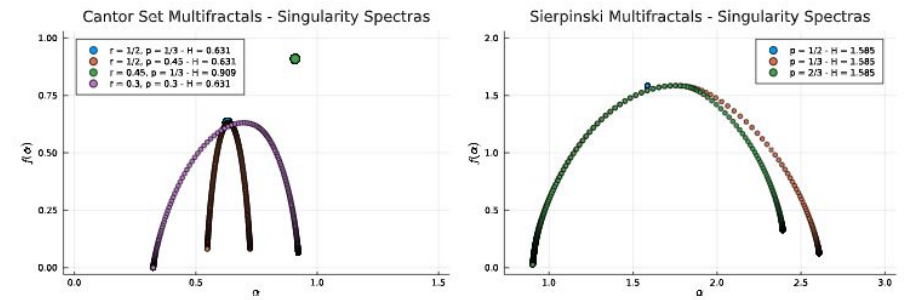

Figure 5: The singularity spectrum of (a) Cantor Set type and (b) Sierpinski triangle type multifractals.

Sándor Lipcsei

Trial & error

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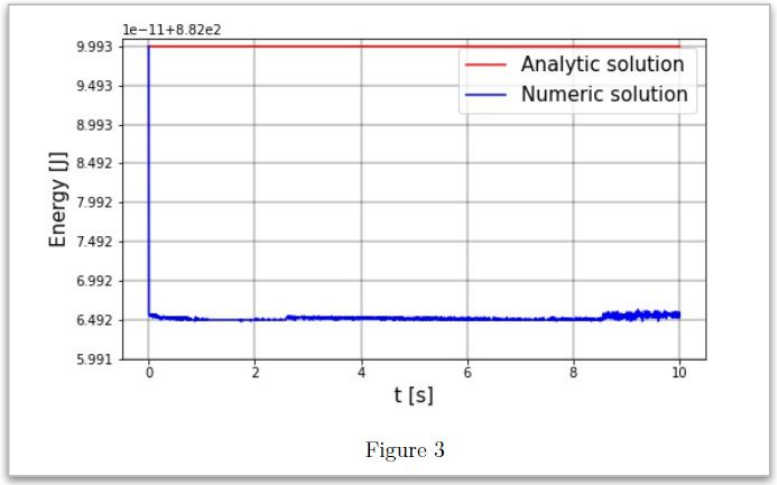

Figure 3

András Balogh

Trial & error

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 SAD

- Finding something strange and not addressing it
- Sweeping anomalies under the rug

Trial & error

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 SAD

- Finding something strange and not addressing it
- Sweeping anomalies under the rug

 MAD

- Giving up
- Code with obvious syntax errors

Language

What makes us...

 HAPPY

- Professional style
- No slang
- Engaging storytelling

Language

What makes us...

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 SAD

- Grammatical mistakes that make your work difficult to follow

Please, ask someone to proofread your paper if you are unsure!

Language

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 SAD

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Please, ask someone to proofread your paper if you are unsure!

 MAD

- TYPOS and other spelling mistakes!
- Hungarian words left in the otherwise English text

Use a spell checker!

Figures

What makes us...

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- Tasteful images that are easy to interpret
- Informative figure legends
- Description of all details

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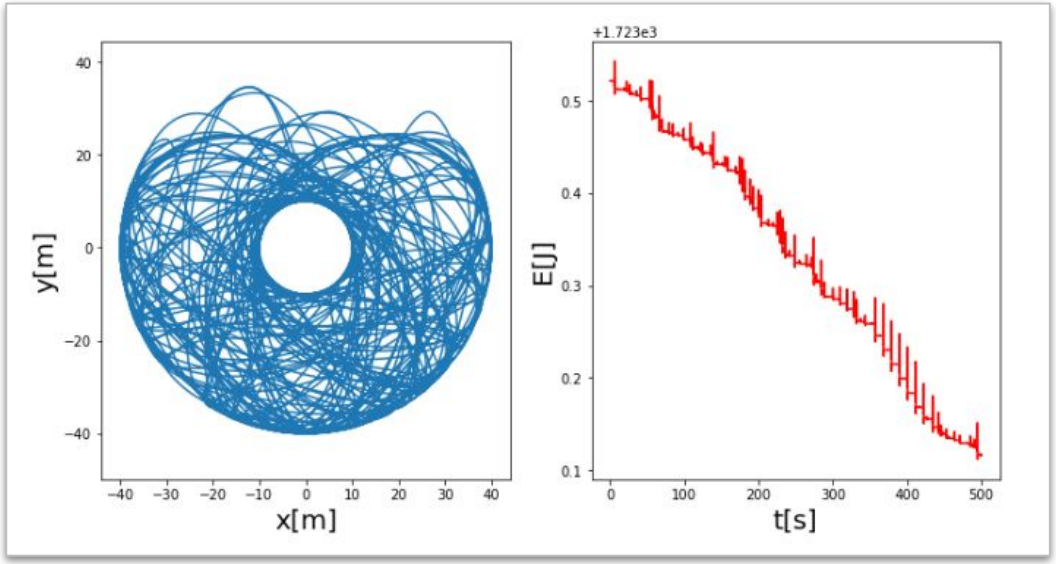

Barnabás Gellért Csillag

Figures

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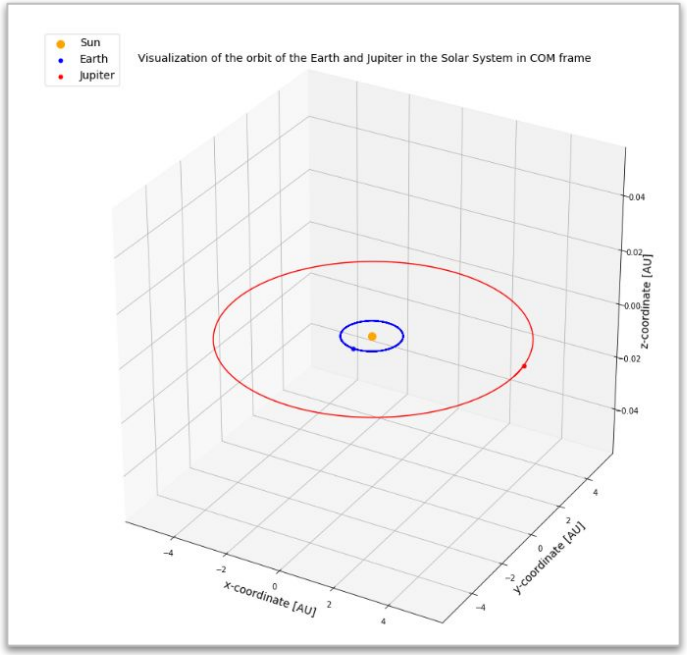

Máté Pszota

Figures

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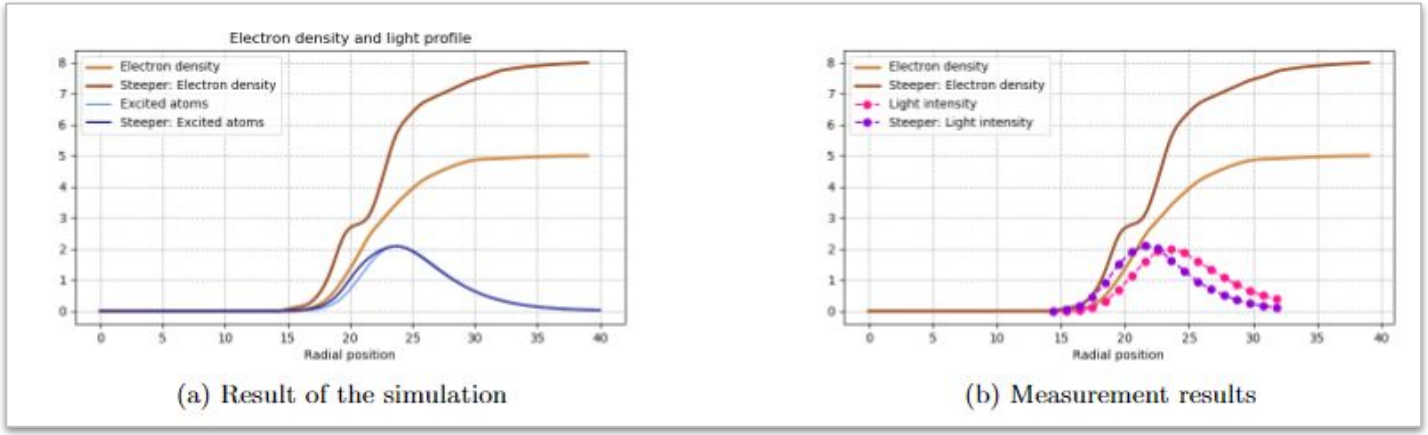

(a) Result of the simulation (b) Measurement results

Lili Édes

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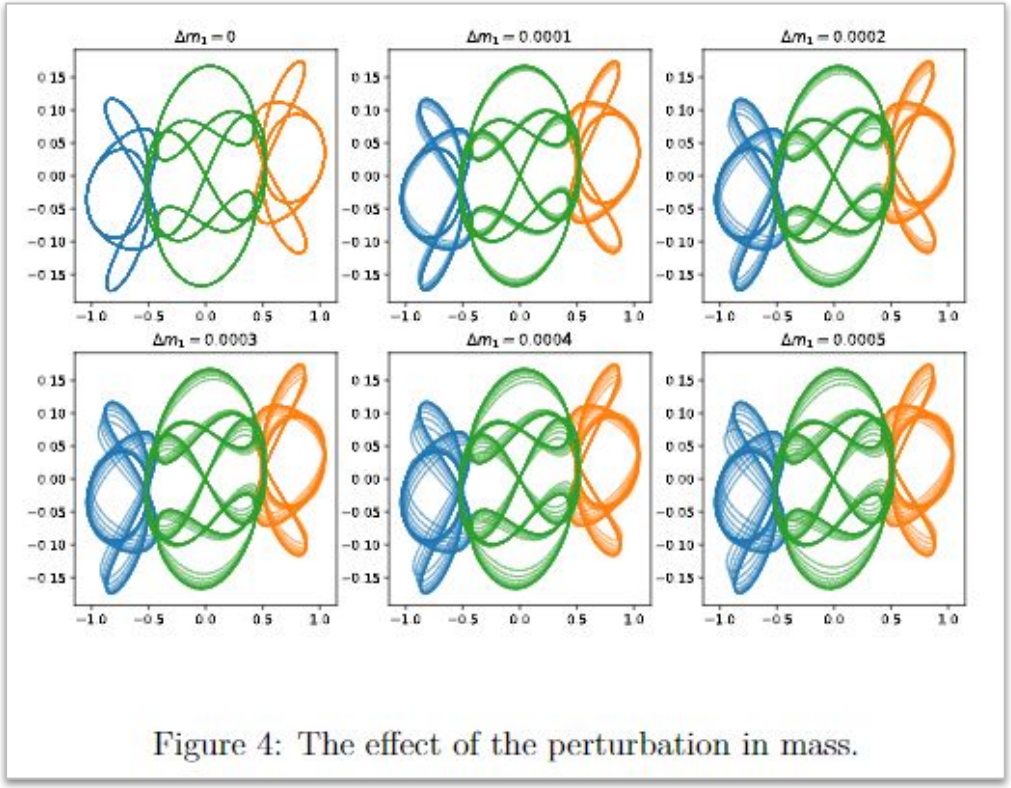

Figure 4: The effect of the perturbation in mass.

György Kálvin

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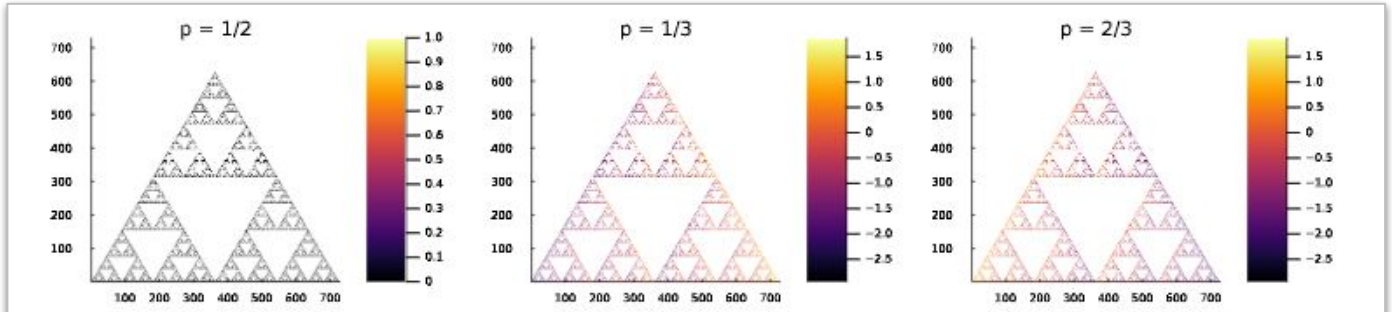

Figure 3: Sierpinski were made by direct geometrical construction. he parameters were from left to right: (a) p = 1/2, (b) p = 1/3 and (c) p = 2/3;

Sándor Lipcsei

Figures

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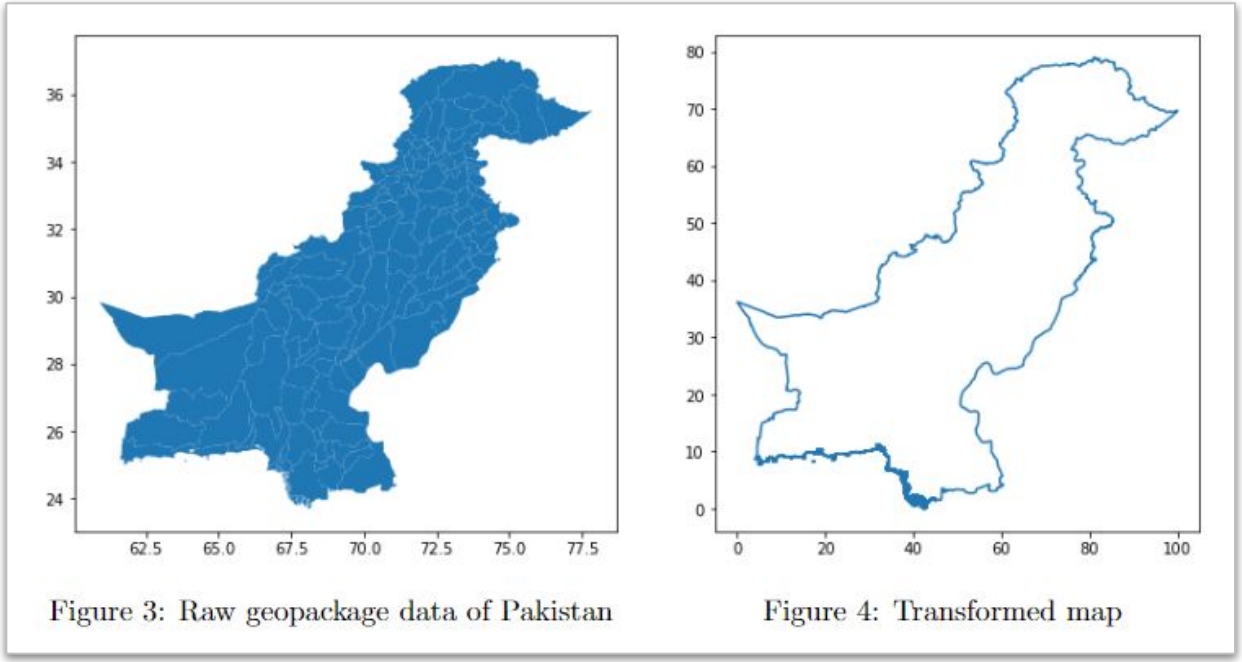

Figure 3: Raw geopackage data of Pakistan

Figure 4: Transformed map

Martin Gyügyi

Figures

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- Informative figure legends
- Description of all details

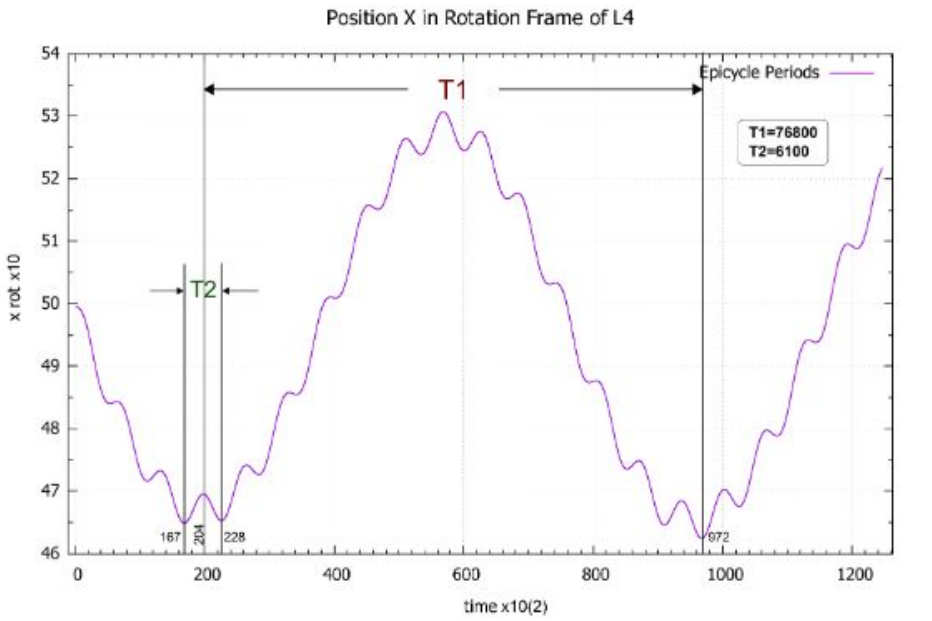


Figure 14 – Periods T1 and T2 of the Epicycle of the Trojan Planet L4.

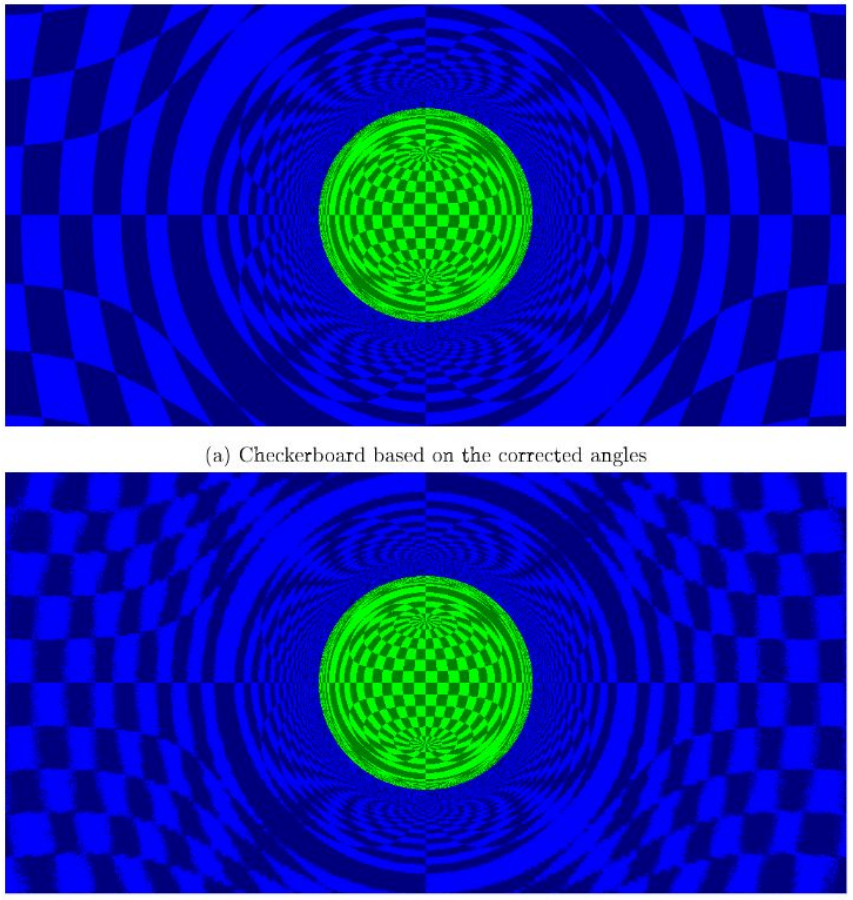
Sebastian Rivas Bello

Figures

What makes us...

HAPPY

- Tasteful images that are easy to interpret
- Informative figure legends
- Description of all details



(a) Checkerboard based on the corrected angles

(b) Checkerboard based on the angles without correction

Figure 4: An image with and without the angle correction step after the collision is determined.

Zoltán Kürti

Figures

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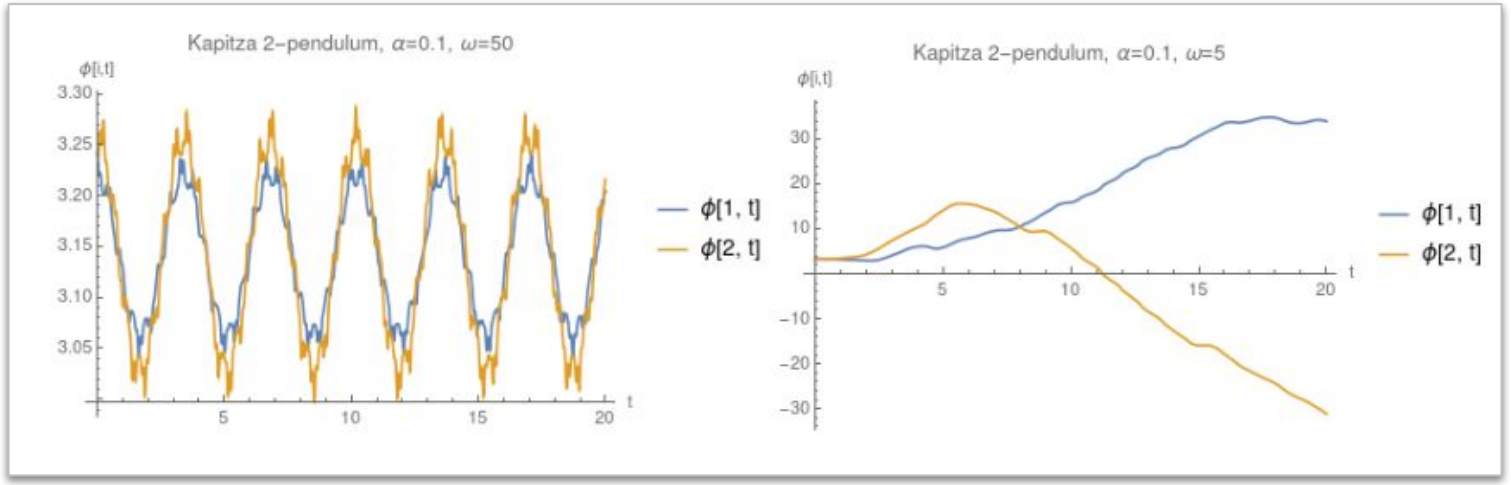

Robin Oberfrank

Figures

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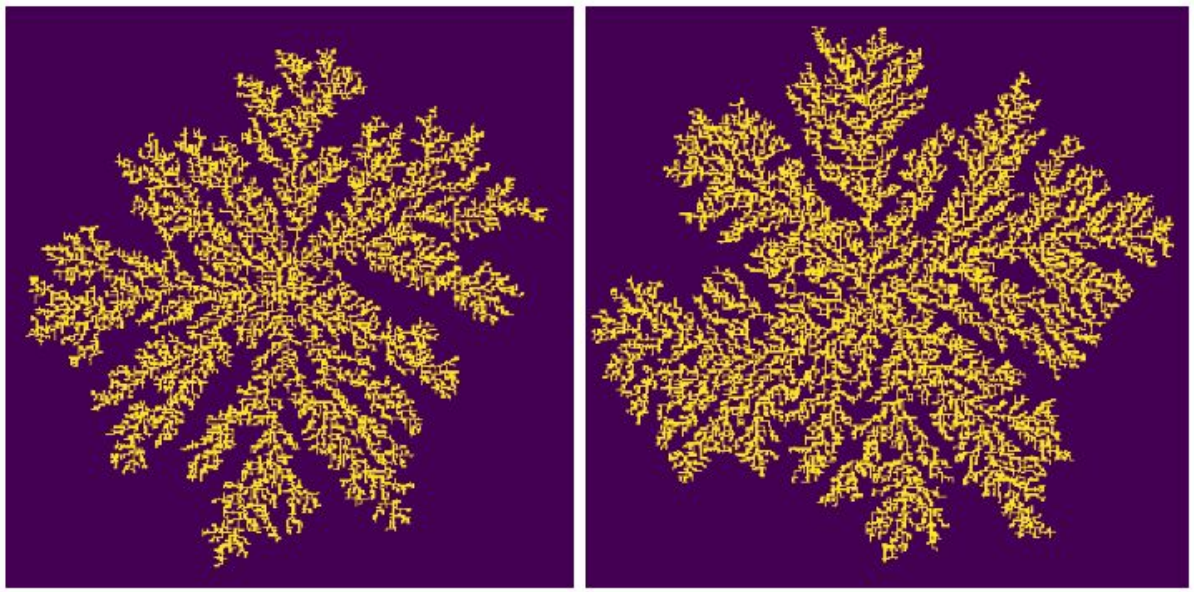

Figure 6: The created fractals using a point-like seed and step lengths from a Lévy alpha-stable distribution with $\alpha = 1.5$ (left) and $\alpha = 1$ (right).

Balázs Kórodi

Figures

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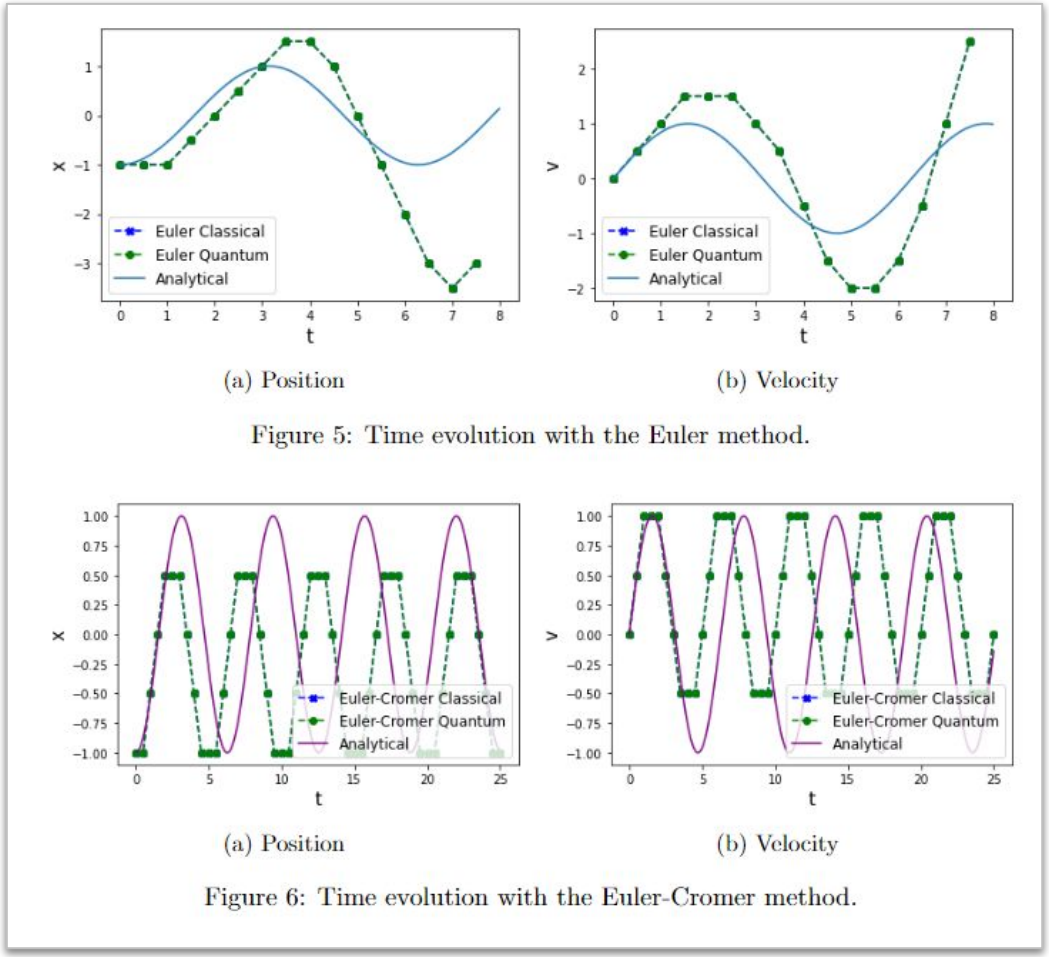

Bence Bakó

Figures

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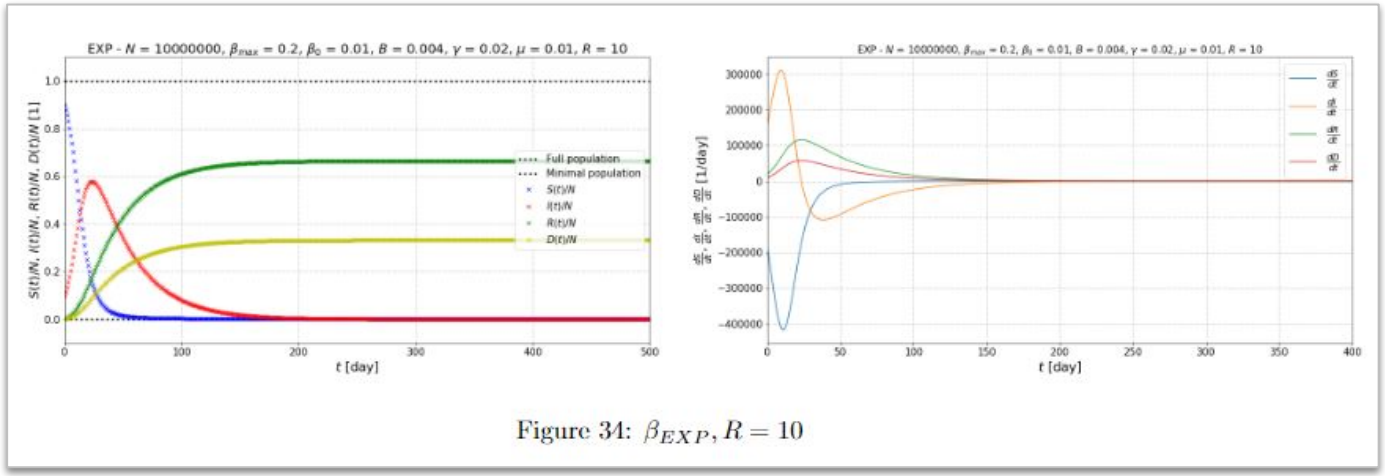

Figure 34: $\beta_{EXP}, R = 10$

Tamás Páhoki

Figures

What makes us...

HAPPY

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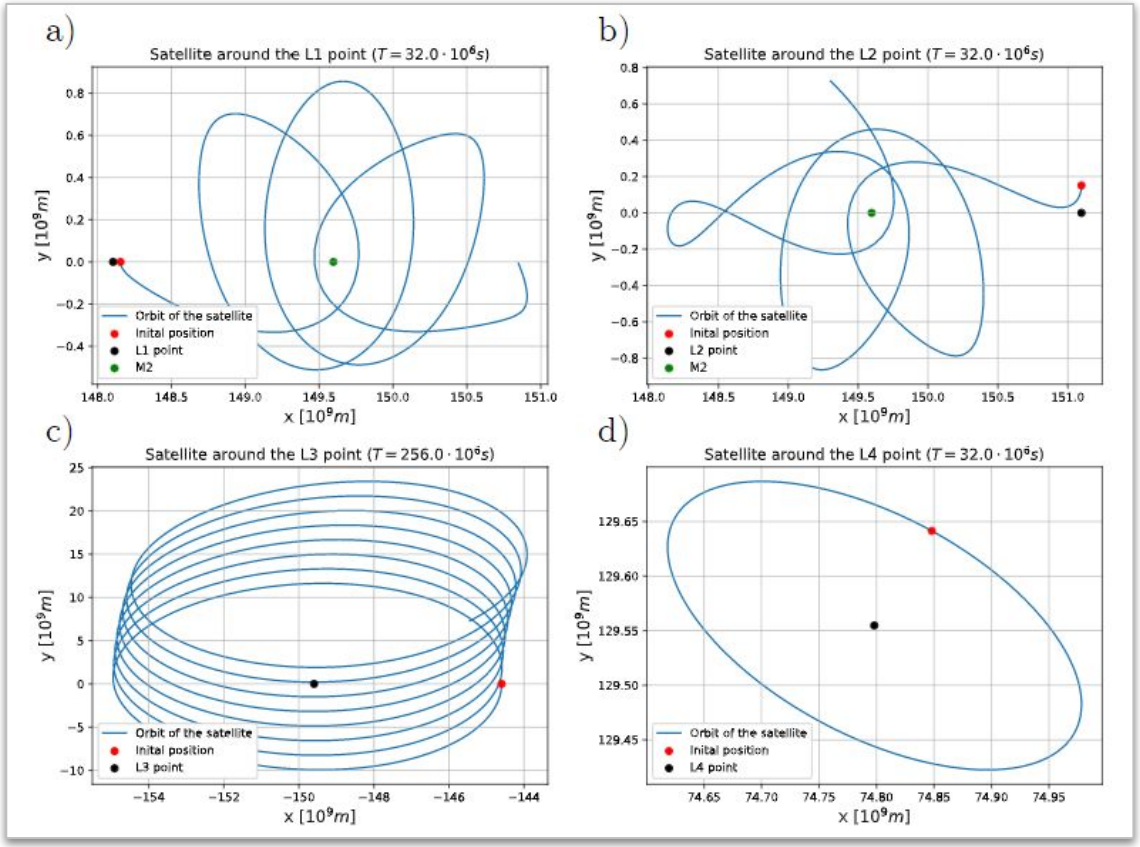
- Description of all details



Márton Karácsony

Figures

What makes us...

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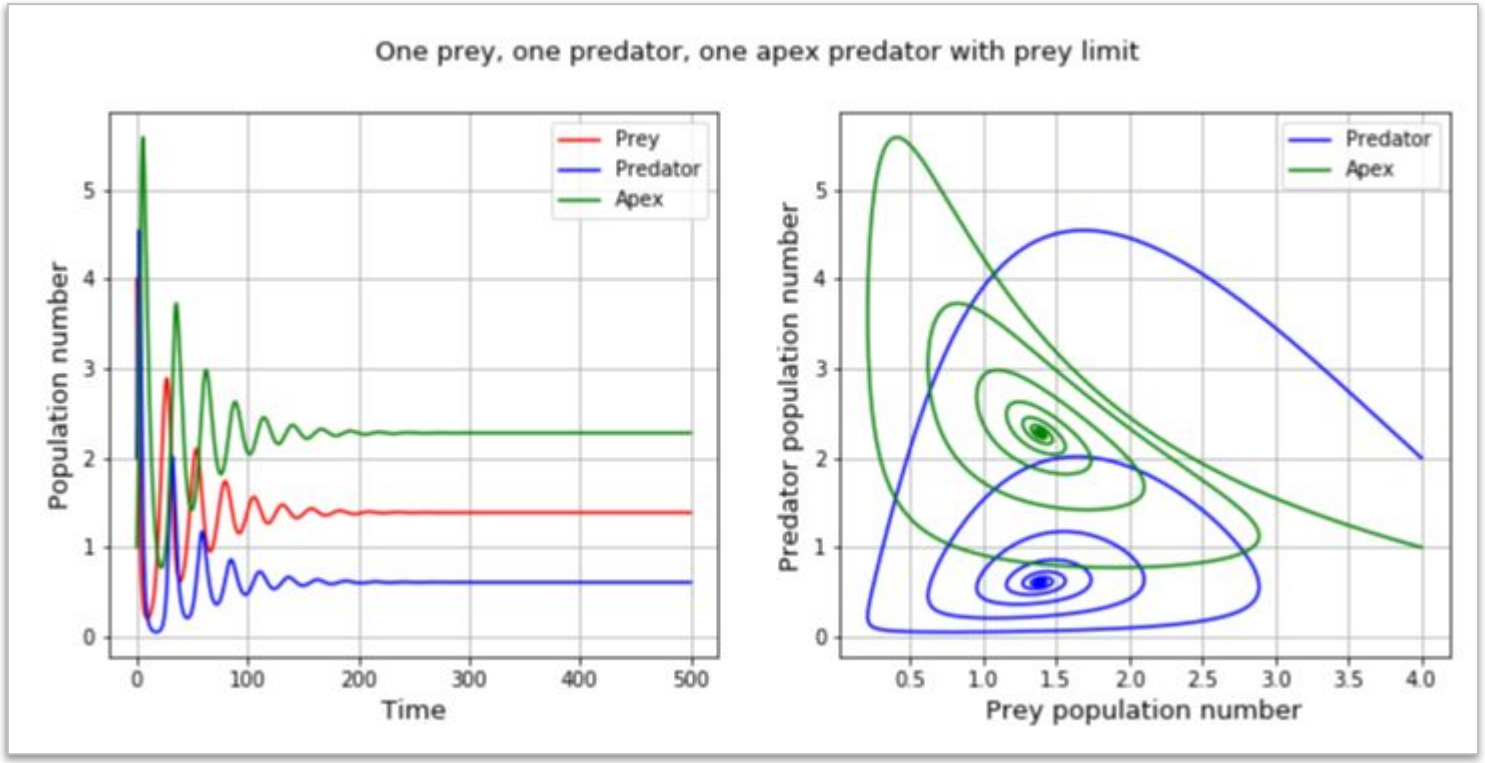

Bendegúz Borkovits

Figures

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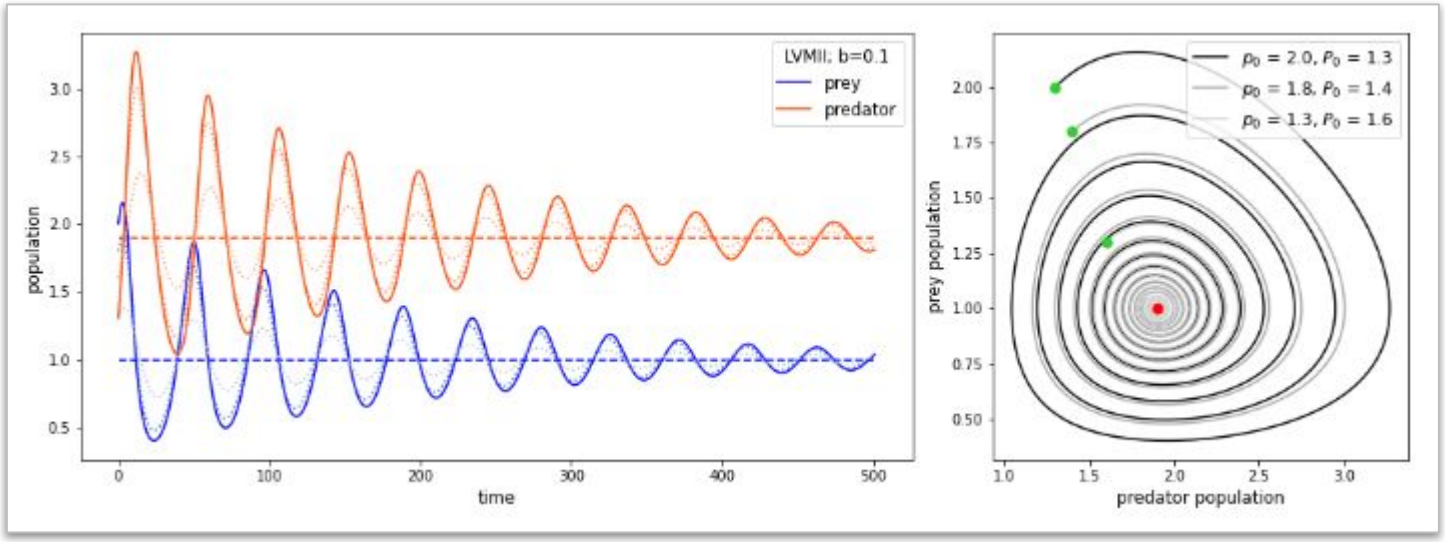

Adrienn Pataki

Figures

What makes us...

HAPPY

- Tasteful images that are easy to interpret
- Informative figure legends
- Description of all details

SAD

- Too small font size for figure labels and text

We're old!

Figures

What makes us...

HAPPY

- Tasteful images that are easy to interpret
- Informative figure legends
- Description of all details

SAD

- Too small font size for figure labels and text

We're old!

MAD

- No axes at all
- No labels on axes
- No units/ticks
- Using many colored curves without any explanation
- Figures not mentioned/unexplained in the text
- Figures copied without reference

Going forward

19th Nov, 2021

Deadline for Project 2

- upload to kooplex-edu
- do not be late
- prepare a concise report
- attach your code as separate files
- make sure your work is reproducible

23rd Nov, 2021

Presentations - day 1

- 10-min presentation
- summarize **both projects**
- basic questions about your projects **and about the course material**

30th Nov, 2021

Presentations - day 2

7th Dec, 2021

Presentations - day 3

Going forward

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Who can present?

- both project reports submitted
- no sign of plagiarism
  (~ a grade of larger than 0)

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- **register** by e-mail (szamszimmsc@gmail.com)
- first come, first served system - **be quick!**

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- first come, first served system - **be quick!**

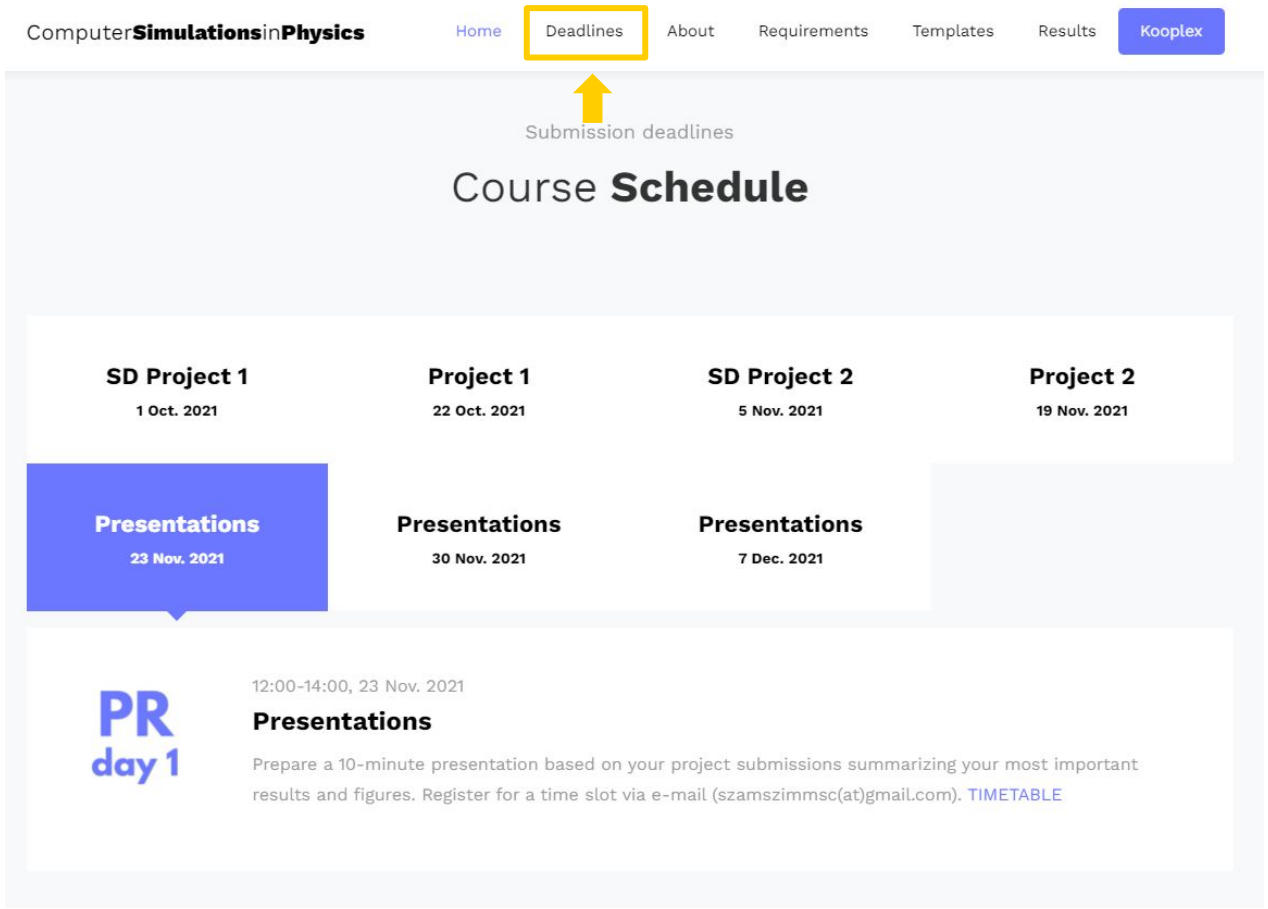
Further options

- **your two project reports have to be submitted and acceptable to get a grade**
- oral examination in the exam period: presenting your projects **and the course material**

Going forward

Registering for a presentation time slot

1) send an **e-mail** to szamszimmsc@gmail.com
2) the e-mail should contain your **name and neptun ID**
3) it should also contain **5 time slots** that are **currently empty** in the table **in the order of your preference**
   example: *day 1 - #6* or *anytime on day 1*
   day 1 - #7 *anytime on day 3*
   day 1 - #8
   day 2 - #10
   day 2 - #11
4) time slots will be assigned in the order of receiving the e-mails (first come, first served)



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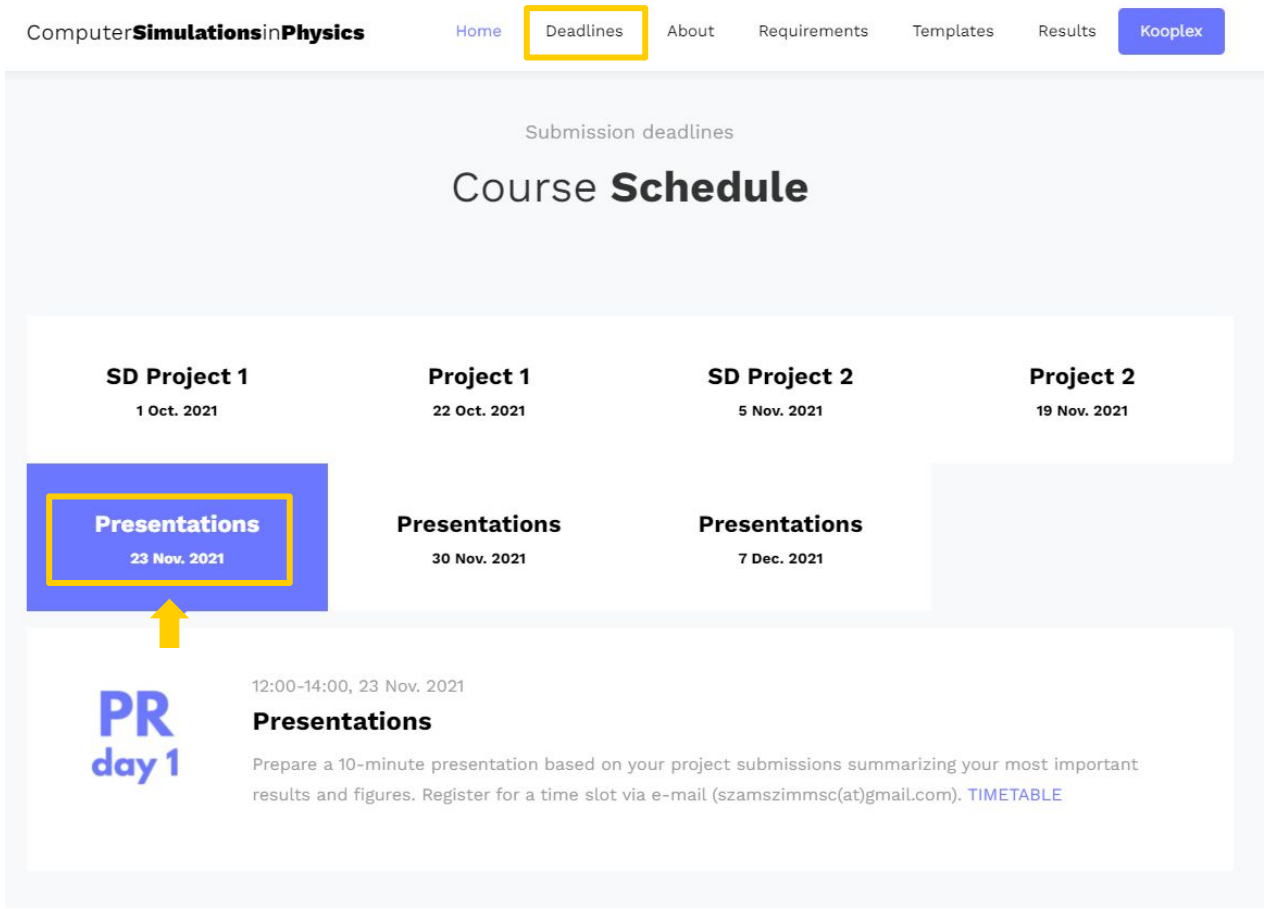

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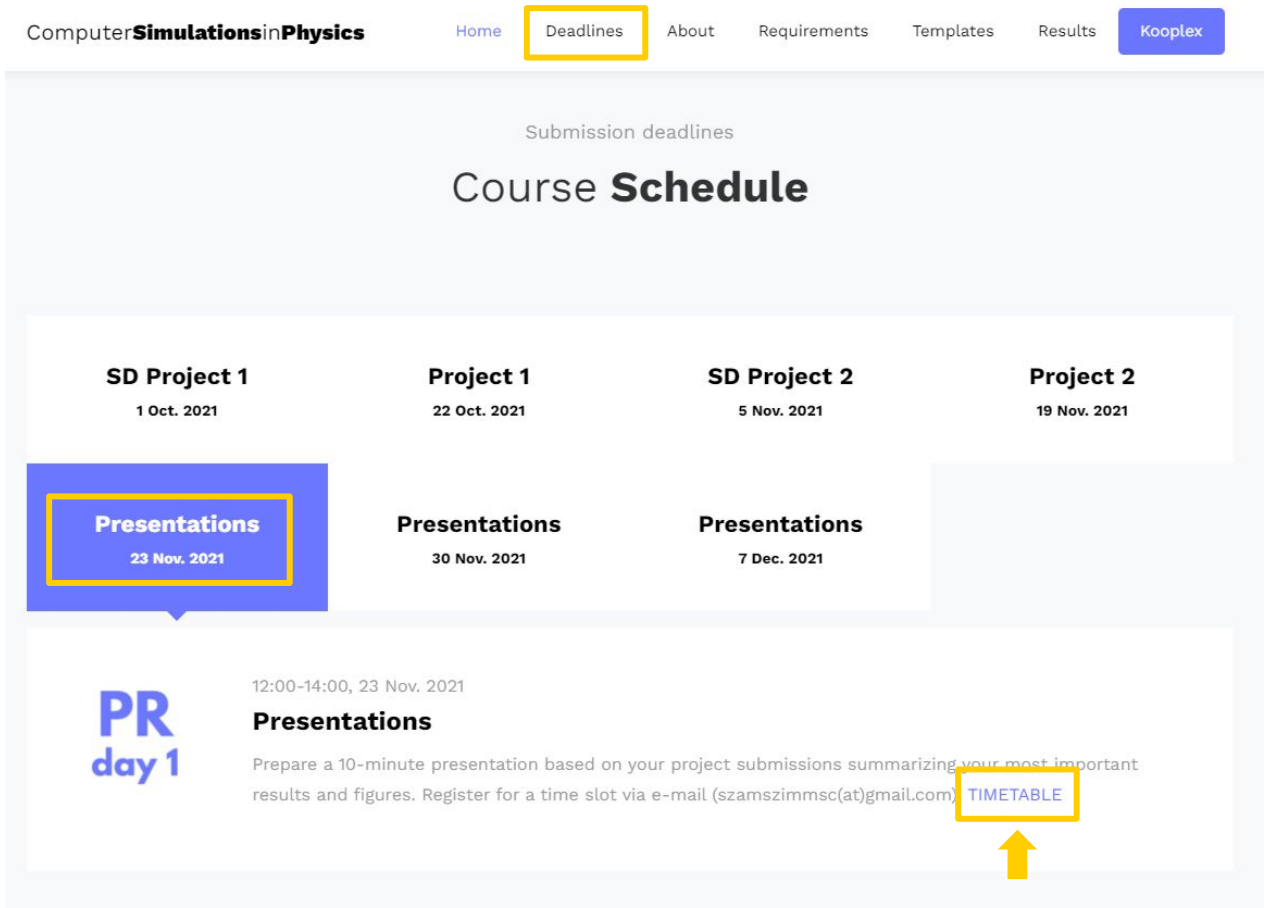

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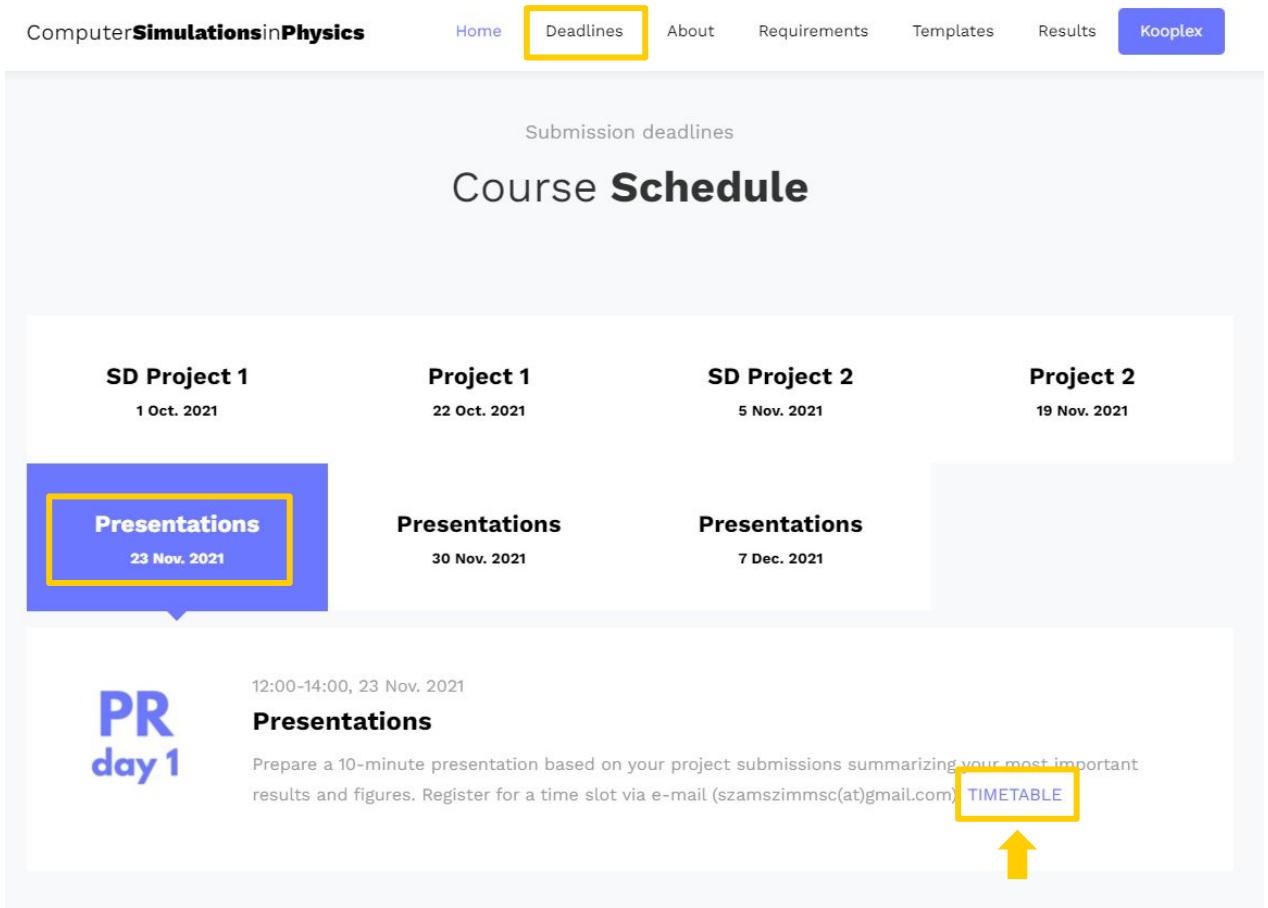

Order	Presentations - day 1 23rd Nov, 2021	Presentations - day 2 30th Nov, 2021	Presentations - day 3 7th Dec, 2021
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

All in all...

Nice work!

Keep faith!

Don’t forget your next assignment!