Mathematical and Natural Sciences
Students Association
of Jagiellonian University

20th Mathematical and Natural Sciences Interdisciplinary Student Conference

SeMPowisko 2022

Book of abstracts and post-conference publication

Kraków, 20–22 May 2022

About us and the event

SeMPowisko is an interdisciplinary conference for students organized every year by the Mathematical and Natural Sciences Students Association of Jagiellonian University. Its goal is to integrate young scientific community, as well as boost the knowledge transfer between different fields of science.

Part of the opening speech by A. Lenart

After 20 years we still uphold the tradition of organizing this conference. Yes, it's already been 20 years since the very beginning of this scientific adventure. Among us is a person who attended the first-ever SeMPowisko conference Prof. Patryk Mach and he can surely tell that this meeting has changed a lot over those 20 years. Humanity has progressed in technology and scientists' perspective on our world has evolved. A lot has changed and a lot has changed for the better. We believe that such development is possible thanks to meetings like this. Small meetings organized by students, for students. Meetings which stimulate creativity, and inspire young people to contribute to science. Some of You might be surprised that we made one conference at which there is present almost every branch of natural sciences and math. It's surely an unusual thing to do. But we saw many times in recent history how different fields can complement each other. The perfect example of such an unusual transfer of knowledge between different fields is how radioastronomy changed medicine. Radioastronomical interferometer became an inspiration for the creation of magnetic resonance imaging. The same idea, which a few days ago gave us the first-ever picture of a black hole in our galaxy allows us to look deep inside the human body. Thus, it is important to create events exactly like this.

Conference plan

Friday, May 20th – room A-1-13

14:00 – 14:30 *Registration — ground floor hall*

Inauguration — 14:00

Part I - Black and Fluorescent — 14:45

14:45 – 15:30 **Modeling matter around black holes**
Prof. Patryk Mach

15:45 – 16:00 **In silico design of novel fluorescent, translation-controlling riboswitches based on the Broccoli aptamer**
Marta Luterek

16:10 – 16:30 *Break*

Part II - Nutrients and Pollutants — 16:30

16:30 – 17:00 **Modulating TOR signaling regulates lifespan in various organisms**
Szymon Biela

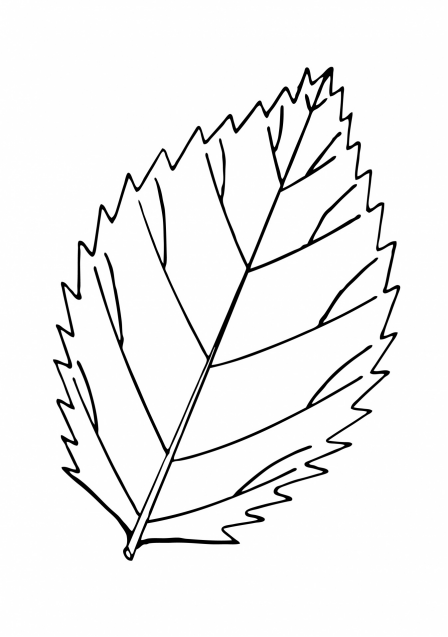
17:10 – 17:40 **Ants Co-Occurring with Predatory Antlions Show Unsuccessful Rescue Behavior towards Captured Nestmates**
Kacper Drożdżak

17:50 – 18:05 **Bioremediation - the degradation of pollutants by microorganism.**
Maria Rybak

18:15 – 18:30 *Break*

Ending Lecture — 18:30

18:30 – 19:15 **How vibrational motion can recognize the pathological state of cells and diseases of affluence?**
Prof. Kamilla Małek



Saturday, May 21st – room A-1-06

09:45 – 10:10 *Registration — ground floor hall*

Second day opening — 10:10

Part III - Machine Learning and Projecting — 10:10

10:10 – 10:55 **Hierarchical correlation reconstruction - between statistics and ML**
Dr. Jarosław Duda

11:10 – 11:20 **A quick overview of Cauchy's Suface Area formula for three-dimensional convex bodies**
Igor Piechowiak

11:30 – 12:00 *Coffee break*

Part IV - Measuring and Error Detection — 12:00

12:00 – 12:30 **Tropical higher dimensions**
Maciej Żurawski

12:40 – 13:10 **(Im)possible puzzle**
Izabela Mandla

13:20 – 13:35 *Break*

Part V - Knots and Folds — 13:35

13:35 – 14:00 **What is possible to knit? Results from topology**
Marta Lotka

14:10 – 14:25 **MoUSE - how to read rodents' minds**
Weronika Ormaniec, Adam Kania, Dmytro Zhylko

14:35 – 15:20 *Lunch break*

Part VI - Infected Chemistry — 15:20

15:20 – 15:35 **SARS-CoV-2 infection in light of the circadian clock**
Joanna Doliwa

15:45 – 15:55 Stimulated Raman Scattering Microscopy – Basics, Development and Perspectives
Jakub Firlej

16:05 – 16:20 Lanthanide-Based Luminescent Thermometers
Paweł Bonarek

16:30 – 16:55 *Coffee break*

Part VII - Craters, Waves and Rats — 16:55

16:55 – 17:05 What can go wrong during rodent surgery: GCaMP6 and epileptiform events
Martyna Pałys

17:10 – 17:25 The evolution of craters on Meridiani Planum, Mars
Szymon Mol

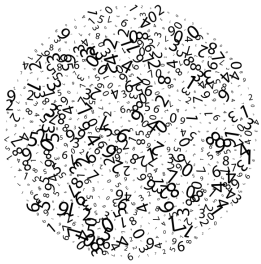
17:35 – 17:50 The concept of Standing Waves in Gravity
Syed Naqvi

18:00 – 18:10 *Break*

Part VIII - Radiophysics — 18:10

18:10 – 18:20 Searching for supermassive black holes with radio eyes
Arpita Misra

18:30 – 18:40 Radioactive watches
Karolina Klimek



Sunday, May 22nd – room A-1-13

09:45 – 10:10 *Registration — ground floor hall*

Third day opening — 10:10

Part IX - High-Speed Physics — 10:10

10:10 – 10:55 **My own little virtual LHC**
Prof. Andrzej Siódmok

11:10 – 11:25 **The Hubble constant tension: still a mistery**
Biagio De Simone

11:35 – 12:00 *Coffee break*

Part X - Rocks Tricked Into Thinking — 12:00

12:00 – 12:30 **Quantum Wasserstein Generative Adversarial Networks and how to buid them**
Rafał Bistroń

12:40 – 13:10 **Sea-level fall and orbital cycles recorded by changes of magnetic susceptibility and calcium carbonate content**
Agata Kuźma

13:20 – 13:35 *Break*

Part XI - Infrared Quants — 13:35

13:35 – 13:50 **Investigation of Physical Properties of LIRGs using Spectral Energy Distribution Modelling**
Subhrata Dey

14:00 – 14:30 **Quantum Key Distribution**
Mateusz Stępniak

14:35 – 15:20 *Lunch break*

Part XII - Cosmological Predictions — 15:20

15:20 – 15:35 Predicting the redshift of gamma ray loud AGNs using machine learning
Aditya Narendra

15:45 – 15:55 Crisis in cosmology and how to solve it
Aleksander Lenart

16:05 – 16:20 How to predict particles masses? – the χQSM model
Maciej Kucab

16:30 – 16:55 *Coffee break*

Part XIII - Scattered and Condensed — 16:55

16:55 – 17:10 Positronium annihilation - how can it be used in different studies?
Ksymena Poradzisz

17:20 – 17:35 Kibble–Zurek Mechanism – Defect formation in condensed matter
Jakub Mazur

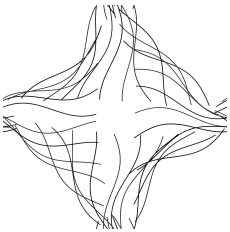
17:45 – 17:55 *Break*

Part XIV - Outside and Inside — 17:55

17:55 – 18:10 LOFAR
Weronika Puchalska

18:20 – 18:35 Your inner amoeba
Piotr Balwierz

18:45 – 18:55 *Ending*



Abstracts

Friday, May 20th

14:45 – 15:30 — Modeling matter around black holes

Prof. Patryk Mach, KMPS UJ, WFAIS, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

How do physicists model matter around black holes? What are the main ways to model the dynamics of gases in strong gravitational fields and how to take into account the self-gravity of the gas? I will try to answer these questions, assuming a perspective of a theoretical physicist. I will explain differences between the Vlasov gas and the hydrodynamical or magnetohydrodynamical approach. I will also show what geometrical (spacetime) effects are to be expected in systems consisting of a black hole and a gas with a sufficiently high mass fraction.

15:45 – 16:00 — In silico design of novel fluorescent, translation-controlling riboswitches based on the Broccoli aptamer

Marta Luterek, KMPS UJ, WFAIS; Mygen, WBBiB, In silico, WBBiB, Faculty of Biochemistry, Biophysics and Biotechnology, Jagiellonian University in Kraków, Poland

Riboswitches are fragments of mRNA molecules that act as regulators of gene expression. This regulation occurs due to the binding of small chemical molecules (ligands). Riboswitches occur naturally in the genomes of e.g. bacteria, for which they are an important part of the regulation of their

metabolism. It is also possible to design synthetic riboswitches. Of particular interest is the design of fluorophore-binding riboswitches.

The aim of my project was to design in silico two complete riboswitch molecules capable of regulating the translation process, based on the sequence of a fluorescent synthetic aptamer called Broccoli. The designed molecules were also subjected to experimental analyses. Based on bioinformatic analyses and preliminary experimental analyses, further modifications were made to the sequences of the constructs, and further bioinformatic analyses were performed.

The riboswitches, after additional modifications, may, among other things, facilitate scientific research on interactions and actions of selected proteins in bacterial cells.

16:30 – 17:00 — Modulating TOR signaling regulates lifespan in various organisms

Szymon Biela, KNBM UW, Faculty of Biology, University of Warsaw, Poland

Studies in multiple model organisms prove that nutrient signaling has a strong influence on aging. With easy access to nutrients organisms grow, develop and age very fast. In case of nutrients deficiency the pace of growth and development of the organisms is slower, what results in longer lifespan. Up to date there are many studies concerning molecular mechanisms of aging. Among several signal transduction pathways concerning this process, TOR (target of rapamycin) pathway is of great significance. TOR is a widely conserved serine/threonine kinase, which by sensing nutrients regulates for example metabolism and cell growth. Multiple metabolites, such as alfa-ketoglutarate and diacylglycerol can inversely modulate TOR pathway and, as a consequence, extend lifespan.

17:10 – 17:40 — Ants Co-Occurring with Predatory Antlions Show Unsuccessful Rescue Behavior towards Captured Nestmates

Kacper Drożdżak, KMPS UJ, WB, Faculty of Biology, Biology, Jagiellonian University in Kraków, Poland

The interaction of antlions and ants is postulated to be a predator-prey interaction in which the involved parties coevolve. Here, we investigated

two issues of potential significance in terms of antlions and ants imposing selective pressures on one another. First, we determined whether trap-building antlions and sand-dwelling ants closely co-occurred in an area inhabited by both. In the field, we found that ants were the main potential prey items in artificial traps placed inside aggregation zones of antlions and that Formica cinerea workers comprised the majority of these ants. Second, we checked whether rescue behavior, a type of prosocial behavior displayed by F. cinerea workers and performed towards nestmates captured by antlions, reduced the hunting success of the latter. In the laboratory, we found that rescue attempts were very rarely successful. Overall, caution must be used when considering the coevolution of antlions and ants. Clearly, even though these two organisms can closely co-occur, the rescue behavior of ants seems to be unrelated to the predatory threat from antlions.

17:50 – 18:05 — Bioremediation - the degradation of pollutants by microorganism.

Maria Rybak, KMPS UJ, WFAIS, Faculty of Biochemistry, Biophysics and Biotechnology

In my short presentation I'd like to introduce the topic of bioremediation. It is very significant matter nowadays which can be for example used to remove the pollutions of soils or water. My talk will briefly explain what is bioremediation, what techniques of bioremediation are used recently and how it can be conducted using micriobiology (especially bacteria and fungi). I am also going to say a little bit about future perspective of bioremediation.

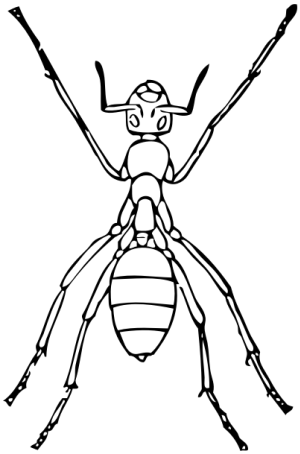
18:30 – 19:15 — How vibrational motion can recognize the pathological state of cells and diseases of affluence?

Prof. Kamilla Małek, WChemUJ, Faculty of Chemistry, Jagiellonian University, Kraków

Fourier Transform Infrared and Raman spectroscopic imaging is set to become a true independent modality for the diagnosis of diseases. The spectroscopic advantage of those techniques lies in the fact that the chemical change must precede or accompany any morphological change that is symptomatic of the disease. The ability to spectroscopically analyze and/or spatially

locate macromolecules within single cells, tissues, and bodily fluids offers a platform to investigate, diagnose and monitor the treatment of several diseases of affluence like cancer and its metastasis, cardiovascular pathologies, and others.

This lecture provides an overview of our latest achievements in the field of FTIR and Raman imaging applied to studies of a plethora of biological specimens derived from in vitro and murine models of civilization diseases and clinical samples. These studies are mainly based on searching for "IR and Raman biomarkers" within the complex vibrational spectra that are indicative of a pathological, physiological, or biological state, which can be used to discriminate statistically classes of samples. Very often, this approach is accompanied by attempts of understanding the biochemical information delivered by spectra and their correlation with the existing diagnostic methods.



Saturday, May 21st

10:10 – 10:55 — Hierarchical correlation reconstruction - between statistics and ML

Dr. Jarosław Duda, KMPS UJ, Faculty of Mathematics and Computer Science, Jagiellonian University in Kraków, Poland

While machine learning techniques are very powerful, they have some weaknesses, like iterative optimization with many local minimums, large freedom of parameters, lack of their interpretability and accuracy control. From the other side we have classical statistics based on moments not having these issues, but providing only a rough description. I will talk about approach which combines their advantages: with MSE-optimal moment-like coefficients, but designed such that we can directly translate them into probability density. For multivariate case such basis of mixed moments asymptotically allows to accurately reconstruct any joint distribution, each coefficient can be independently and cheaply estimated, has a clear interpretation, and we have some control of its accuracy. I will also present its two applications: systematic enhancement of ARMA/ARCH-like modeling for any mixed moments and non-stationary time series, and for credibility evaluation of income data: modeling continuous conditional probability distribution from a large number of variables of various types.

11:10 – 11:20 — A quick overview of Cauchy's Surface Area formula for three-dimensional convex bodies

Igor Piechowiak, KMPS UJ, Faculty of Mathematics and Computer Science, Jagiellonian University in Kraków, Poland

This talk with swiftly introduce primarily the intuition and possible applications of Cauchy's surface area formula, stating that for an n-dimensional solid S the surface area can be calculated as exactly $\frac{1}{4} \cdot A_p$, where A_p is the average of areas of all possible projections of S onto a fixed plane.

12:00 – 12:30 — Tropical higher dimensions

Maciej Żurawski, KMPS UJ, Faculty of Mathematics and Computer Science, Jagiellonian University in Kraków, Poland

Concept of fidelity is greatly important in Quantum Information Theory. I would like to present classical and quantum approach to this measure and with the use of measure theory explain the results obtained by simulations. One of the results is that in higher dimensions most of the surface of the sphere is covered by tropical zones.

12:40 – 13:10 — (Im)possible puzzle

Izabela Mandla, KMPS UJ, WFAIS, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

Two prisoners and one guard who loves logic. It may sound like the beginning of many puzzles that we are familiar with. This time, to gain freedom, prisoners will have to solve a problem that is connected to the chessboard. The problem that may seem impossible to solve. But is it really so? And how does any of this have anything to do with error detection and correction?

13:35 – 14:00 — What is possible to knit? Results from topology

Marta Lotka, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

The issue of knittability as a topological property can be considered from two perspectives: 1) knittability of stitches understood as knots, and 2) possibility of representing topological surfaces (or rather their immersions in 3-dimensional space) with knitted fabric. This talk will review crucial results in both fields, in particular the framework by [1] for representing knitted stitches, and the proof by [2] that all topological surfaces can be represented using techniques intrinsic to the craft of knitting. Connection of these results to biomedical engineering will also be briefly discussed.

14:10 – 14:25 — MoUSE - how to read rodents' minds

Weronika Ormaniec, Adam Kania, Faculty of Mathematics and Computer Science, Jagiellonian University in Kraków, Poland; Dmytro Zhylko, BIT AGH, WIET, Faculty of Computer Science, Electronics and Telecommunications, AGH Univercity of Science and Technology, Poland

We present the project that aims to address the issue of manual analysis of recordings from experiments on rodents (mainly for pharmacological purposes) by introducing automatic methods of ultrasonic vocalization (USV) detection and classification. The solution supports two methods of USV classification and detection. Algorithms were tested on real world data, which presents additional obstacles like noise from mice cage or mice in nearby cages. That's why we also present a few denoising algorithms to facilitate automatic detection.

We are planning to make our work publicly available under open source license in the form of Python packages and desktop applications.

15:20 – 15:35 — SARS-CoV-2 infection in light of the circadian clock

Joanna Doliwa, KMPS UJ, WFAIS, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

Circadian clock is an endogenous biochemical oscillator that cycles with a stable phase, is synchronised by solar light, and runs with a period of approximately 24 hours. It is known to play an important role in regulating various aspects of viral infections such as viral replication and host responses. Standing in the midst of the COVID-19 pandemic, one may wonder what the specific interplays between the SARS-CoV-2 infection and the human circadian clock are. Here I review the role of circadian clock proteins in SARS-CoV-2 entry and replication, as well as the possibility of perturbation of host circadian rythms due to the infection. Based on this information, I evaluate possible candidates for antiviral drugs. I then look at how timing of SARS-CoV-2 vaccination and drug dosing may affect their efficacy. Finally, I explain the effect of circadian disruption, which affects for example night shift workers, on the severity of developed COVID-19 symptoms.

15:45 – 15:55 — Stimulated Raman Scattering Microscopy – Basics, Development and Perspectives

Jakub Firlej, KMPS UJ, WFAIS, Faculty of Chemistry, Jagiellonian University in Kraków, Poland

Stimulated Raman Scattering (SRS), a part of set of modern micro-

scopic techniques called SRS microscopy, has a profound impact on fields like chemistry, biology or biomedicine. For example, there has been pilot studies conducted in quick intraoperative brain tumour histopathology based on AI supported SRS microscopy.

Two pulsed laser beams which frequency difference matches the molecular vibrational frequency is required to observe SRS phenomenon. Although it sounds like a simple idea, construction of efficiently working SRS microscope is far from easy.

In this speech, basics of SRS phenomenon will be discussed. Furthermore, construction of SRS microscope used by Raman Imaging Group at Jagiellonian University will be shown. Last but not least, perspectives on SRS microscopy usage will be proposed.

16:05 – 16:20 — Lanthanide-Based Luminescent Thermometers

Paweł Bonarek, KMPS UJ, WChUJ, Faculty of Chemistry, Jagiellonian University in Kraków, Poland

Lanthanide MOFs showing temperature dependence of luminescence are a promising source of sensitive nanothermometers. They allow for contactless temperature scan with heigh spatial resolution and may find utilization in nanomedicine, polymer composite preparation, or inkjet printable films. In this presentation, I would like to introduce the subject of lanthanide-based luminescent thermometers by succinctly explaining how they work, how to they are synthesized and what can be done to improve their performance. It will be illustrated with some examples, and comments about potential uses will be added. Finally, I will mention future challenges in the field.

16:55 – 17:05 — What can go wrong during rodent surgery: GCaMP6 and epileptiform events

Martyna Pałys, Neuroinformatics Student Club, Faculty of Physics, University of Warsaw, Inter-faculty Individual Studies in Mathematics and Natural Sciences, University of Warsaw, Poland

GCaMP6 is a genetically encoded calcium indicatior which is used in biological research to measure intracellular Ca2+ levels in nerve cells. It is observed that in experiments with using GCaMP increases the numer of

epileptiform events in hippocampal CA1 area. The causes of this phenonenon remain still unclear.

17:10 – 17:25 — The evolution of craters on Meridiani Planum, Mars

Szymon Mol, KMPS UJ, WFAIS, Faculty of Geography and Geology, Jagiellonian University in Kraków, Poland

Impacts are the most common geologic processes in the Solar System. Even though their effects are rarely visible on Earth, craters might be easily observed on other planetary bodies. Meridiani Planum is a playa-type plain in the equatorial areas of Mars. It was visited and explored by the Opportunity rover in 2004-2018. Along her traverse there are a couple of hundreds impact craters. They vary in size, shape, age and the level of erosion. In my talk I will present how craters are being modified by degradational processes based on data from the rover cameras, HiRISE experiment and digital terrain model prepared in collaboration with scientists from Warsaw University of Technology. The work was funded by the Anthropocene Priority Research Area budget under the program "Excellence Initiative – Research University" at the Jagiellonian University.

17:35 – 17:50 — The concept of Standing Waves in Gravity

Syed Naqvi, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

Standing waves are a very interesting phenomenon in Physics. When two waves meet, there are regions of maximum and minimum displacements. These regions, known as, antinodes and nodes, lead to many interesting phenomena from wiggly patterns you can make on a string tied on one end to a guitar string or flute producing music to trapping particles by lasers. We study the concept of standing waves in Einstein's theory of gravity. Einstein's theory, known as the general theory of relativity predicted the existence of gravitational waves which were experimental discovered recently. So it is interesting to probe the question of whether two interacting gravitational waves form standing waves? This study of standing gravitational waves provides a glimpse into the complexities involved in Einstein's equations and will throw

light into their non-linear nature.

18:10 – 18:20 — Searching for supermassive black holes with radio eyes

Arpita Misra, Astronomical Observatory of Jagiellonian University, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

How do you see something that emits no light? How do you measure the mass and size of such an object? With the advent of radio telescopes, we can now peer directly into the heart of a galaxy that often hides a supermassive black hole. In this talk, I intend to explain how we image massive black holes and what we can understand from them. I will discuss about the recent radio observations of SagA* by the Event Horizon Telescope and briefly talk about other supermassive black holes that we observe in distant galaxies.

18:30 – 18:40 — Radioactive watches

Karolina Klimek, KMPS UJ, WFAIS, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

After Maria and Pierre Curie had discovered a chemical element radium, it became wildely used in everyday life. Radium was added for example to chocolate, toothpaste, bread and lots of different things. It was also used to produce luminescent watches. In factories, which produced such watches, were working usually young women. They had to paint dials and hands of the watches with paint, which included radium and zinc sulfide (ZnS). This combination caused, that watches emitted light. This work was quite easy and well-paid. Young girls were not aware of dangerous radiation emitted by radium. Over time they got sick and started dying...

In my presentation I will tell more about history of this luminescent watches. I will also explain, why accually such watches were emitting light. Additionally I will show the analysis of energy spectrum emitted by two old watches available at the Faculty of Physics at Jagiellonian University. During my presentation you could see identification of radioactive elements included in that watches. Will it be radium?

Sunday, May 22nd

10:10 – 10:55 — My own little virtual LHC

Prof. Andrzej Siódmok, KMPS UJ, WFAIS, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

11:10 – 11:25 — The Hubble constant tension: still a mistery

Biagio De Simone, Astrophysics, (1) Department of Physics "E.R. Caianiello", University of Salerno (Italy); (2) INFN

The difference from 4 to 6 σ in the Hubble constant (H_0) between the values observed with the local (Cepheids and Supernovae Ia, SNe Ia) and the high-z probes (CMB obtained by the Planck data) still challenges the astrophysics and cosmology community. Previous analysis has shown that there is an evolution in the Hubble constant that scales as $f(z) = H_0'/(1+z)^\eta$, where H_0' is $H_0(z=0)$ and η is the evolutionary parameter. Here, we investigate if this evolution still holds by using the SNe Ia gathered in the Pantheon sample and the Baryon Acoustic Oscillations (BAOs). We assume $H_0 = 70\,kms^{-1}Mpc^{-1}$ as the local value and divide the Pantheon into 3 bins ordered in increasing values of redshift. Similar to our previous analysis but varying two cosmological parameters contemporaneously (H_0, Ω_{0m} in the ΛCDM model and H_0, w_a in the w_0w_aCDM model), for each bin we implement a MCMC analysis obtaining the value of H_0. Subsequently, the values of H_0 are fitted with the model $f(z)$. Our results show that a decreasing trend with $\eta \sim 10^{-2}$ is still visible in this sample.

12:00 – 12:30 — Quantum Wasserstein Generative Adversarial Networks and how to buid them

Rafał Bistroń, KMPS UJ, WFAIS, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

Quantum Computing and Machine Learning are the fastest-growing fields in science. The idea to merge them comes as no surprise. One of the motivations to do so is the efficient generation of arbitrary (approximate)

quantum states of complicated systems, for example in quantum chemistry. A natural candidate for the solution of such a problem would be a quantum analogue of Generative Adversarial Networks. However, current studies strongly suggest that they share many of the obstacles of the 'original' GANs, especially the instability in the learning process.

To deal with these problems several modifications of GANs were proposed e.g. Wasserstein GAN, which experience much more stable training for the cost of a fixed Discriminator structure build to calculate the Wasserstein distance. In my talk, we will discuss the basic ingredients of the first successful design of quantum Wasserstein Generative Adversarial Networks (qWGAN), which has been shown to improve the robustness and the scalability of the adversarial training of quantum generative models even on noisy quantum hardware.

12:40 – 13:10 — Sea-level fall and orbital cycles recorded by changes of magnetic susceptibility and calcium carbonate content

Agata Kuźma, KNGS UJ, WGiG, Faculty of Geography and Geology, Institute of Geological Sciences, Jagiellonian University, Gronostajowa 3a; 30-387 Kraków, Poland

Agata Kuźma, Krzysztof Ninard, Łukasz Weryński, Agata Biała, Julia Dziewońska, Julia Krzyżowska

The siliceous marl succession exposed in the Piotrawin quarry (Eastern Poland) is macroscopically monotonous. Our contribution is aimed at the extraction of trends and cyclicity from the sedimentary record based on a quantitative approach. For the first time, we provide a high-resolution record of magnetic susceptibility (MS) and calcium carbonate content changes from the Piotrawin site. A set of complementary statistical, multivariate, and time series analysis methods was used to investigate the interrelation of measured variables and detect patterns in them. Orbital cyclicities are identified by the means of Multi-taper Method-based spectral analysis and multivariate Singular Spectrum Analysis (SSA). The short eccentricity cycles recorded in the whole rock succession were reconstructed using the gap-filling SSA technique. An average sedimentation rate is statistically determined at 1.5-2 cm/kyr. The time span of its deposition is estimated at 1.3-1.7 Myr, based on both sedimentation rate estimates and the counts of short eccentricity cycles identified.

13:35 – 13:50 — Investigation of Physical Properties of LIRGs using Spectral Energy Distribution Modelling

Subhrata Dey, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian /university in Kraków

Luminous Infrared Galaxies (LIRGS) offer unique laboratories to understand various physical processes which drive the evolution of galaxies across cosmic times as they form a bridge between the normal star-forming galaxies and the Ultra-Luminous Infrared Galaxies. We report the physical properties of 11 LIRGs.We utilized multi-wavelength photometric archival data and applied Code Investigating GALaxy Emission (CIGALE) to extract the physical parameters of each system.Our results are following:1) from the CIGALE modeling, the median values of AGN fraction, SFR, dust luminosity, stellar mass and the infrared to radio luminosity (at 1.4 GHz) ratio are, 5%, 1.3 Msun/yr, 11.05 Lsun, 10.47 Msun, and 2.5, respectively, compared to those reported in the literature,2)majority of our galaxies show up to few percent thermal fraction,3) the mean synchrotron spectral index from the CIGALE modeling turns out to be -0.9 which is steeper than the canonical value of -0.7.

14:00 – 14:30 — Quantum Key Distribution

Mateusz Stępniak, KMPS UJ, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

Quantum key distribution (QKD) is a secure communication method which implements a cryptographic protocol involving components of quantum mechanics. It enables two parties to produce a shared random secret key known only to them, which can then be used to encrypt and decrypt messages. I will present most popular methods and protocols used in QKD that are consider to be used in real quantum networks.

15:20 – 15:35 — Predicting the redshift of gamma ray loud AGNs using machine learning

Aditya Narendra, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian /university in Kraków

Active Galactic Nucleis (AGN) are one of the most luminous and powerful objects in the universe. In this work we use the AGNs observed by the Fermi space satellite to train a supervised machine learning model such that it predicts the redshift of these AGNs without requiring extensive spectroscopic measurements.

15:45 – 15:55 — Crisis in cosmology and how to solve it

Aleksander Lenart, KMPS UJ, WFAIS, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

How much are we biased in cosmological observations? Why do different measurements not agree with each other? What are we doing wrong? How can we extend our measurements? Are Gamma-Ray Burst and Quasars a hope for the solution to those mysteries? The newest procedures aiming to remove the selection bias and "redshift evolution" from the data might be a key to the puzzle, but how much work do we still have to do in order to make any progress?

16:05 – 16:20 — How to predict particles masses? – the χQSM model

Maciej Kucab, KMPS UJ, WFAIS, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

Hadrons are particles in which quarks and gluons are bound by strong interactions. Quantum Chromodynamics describing strong interactions is almost not applicable in the low level limit. Therefore, to calculate masses of baryons we need to employ a model which describes effectively strong interactions. An example of such a model is a model called chiral quark soliton model (χQSM). The solution of the Dirac equation with mean chiral field, called chiral soliton, has SU(2)×SU(3) global symmetry. Parameters of this hamiltonian (such as moments of inertia) can be calculated from the Dirac equation. I have treated those parameters as free parameters to be fit to the experimental data. This presentation will be started by bringing out the theoretical background and physical intuition about χQSM. I will explain how the eigenvalues of dirac equation are derived and how we can obtain the predictions for heavy pentaquarks masses, and what to do next to prove

experimentally that they are correct.

16:55 – 17:10 — Positronium annihilation - how can it be used in different studies?

Ksymena Poradzisz, KMPS UJ, WFAIS, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

In positronium annihilation there are created photons. The number which can be created in this event is determined by spin of positronium, at least we think it is Depending on spin value we call it para- or orthopositronium. In my presentation I will say how positronium annihilation can be used in different studies such as quantum entanglement phenomenon or breaking CPT symmetry.

17:20 – 17:35 — Kibble–Zurek Mechanism – Defect formation in condensed matter

Jakub Mazur, KMPS UJ, WFAIS, Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

This talk will lay a foundation for understanding Kibble—Zurek Mechanism (KZM), a theory that describes the defects formation during the second—order phase transition with finite transition rate. This mechanism biggest advantage is its universality, as knowing only basic parameters of a system we can estimate properities of a system after transition to ordered phase.

The talk will consist of two parts. First one will be gentle introduction into quantitive description of KZM, second one will consist of intuitive look at this mechanism and some real life and computational examples.

17:55 – 18:10 — LOFAR

Weronika Puchalska, KNSA; SPIE NCU Student Chapter; WFAiIS, Nicolaus Copernicus University in Toruń

When thinking of radio telescope, most people picture of a large parabolic antenna, such as RT4 in Piwnice or Effelsberg in Germany.

However, interferometers (radio telescope networks) are being used to obtain high-resolution images. An example of this is LOFAR (Low Frequency Array), which unlike classical radio telescopes, consists of many individual dipole antennas.

It is also characterized by the fact that it has no moving parts, so it is much cheaper to maintain and rarely breaks down.

During my internship at the LOFAR station in Bałdy near Olsztyn, I had opportunity to see this simple but brilliant construction.

18:20 – 18:35 — Your inner amoeba

Piotr Balwierz, KMPS UJ, Institute of Clinical Sciences, Imperial College London, London, United Kingdom

Regulation of gene expression in eukaryotes is a sophisticated multilevel process. At the core of the process is the initiation of transcription of messenger RNA from DNA. In bacteria and unicellular eukaryotes, gene expression program is largely encoded in the DNA sequence directly upstream of gene start, called proximal gene promoter.

All multicellular organisms are known to use additionally long-range DNA looping.This looping mechanism provides additional DNA sequence space and complexity necessary for encoding developmental gene expression programs.

We investigated a rare and very special kind of cell in zebrafish body (a model organism in developmental biology), a primordial germ cell (PGC). Several genome-wide assays showed that PGCs have gene expression regulation very much like single cell organisms. There are little regulatory elements compared to cells that form the rest of the body. Moreover, these elements are located nearby to gene promoters and are enriched in structural DNA motifs instead of gene-regulatory motifs, suggesting that, unlike all other cells, DNA looping is not necessary for gene expression regulation in PGCs.

Publications

The concept of standing waves in gravity

Syed U. Naqvi, *Department of Relativistic Astrophysics and Cosmology, Astronomical Observatory of the Jagiellonian University in Kraków, Poland*

Standing waves are a very interesting phenomenon in Physics. When two waves meet, there are regions of maximum and minimum displacements. These regions, known as, antinodes and nodes, lead to many interesting phenomena from wiggly patterns you can make on a string tied on one end to a guitar string or flute producing music to trapping particles by lasers. We study the concept of standing waves [1] in Einstein's theory of gravity. Einstein's theory, known as the general theory of relativity predicted the existence of gravitational waves which were experimental discovered recently. So it is interesting to probe the question of whether two interacting gravitational waves form standing waves? This study of standing gravitational waves provides a glimpse into the complexities involved in Einstein's equations and will throw light into their non-linear nature.

Introduction

General Relativity is the theory describing gravity in terms of the geometry of spacetime. The three spatial dimensions and one-time dimensions are bought on equal footing which makes up this spacetime. Earlier the fundamental interactions used to be studied where spacetime was a background stage and particles and fields were the main characters. Now in the study of gravity, spacetime itself becomes an active participant. These spacetimes are solutions of the Einstein field equations, which relate the curvature of spacetime to the matter present in it. There exist many solutions to Einstein's field

equations– like expanding universe, the spacetime of a spherically symmetric body, and wave-like solutions known as gravitational waves.

The phenomena of standing waves are well known in mechanical and electromagnetic settings where the wave has the maximum and minimum amplitude at the antinodes and nodes, respectively. In the context of the exact solution to Einstein's field equations, we analyze a spacetime that represents standing gravitational waves in an expanding Universe.

When you give a quick, sudden movement to a string tied to a wall or when you pluck a string on a guitar, standing waves are produced. In the context of Gravity, there exist these ripples of spacetime known as Gravitational waves. One can then raise the question of whether standing gravitational waves exist. More precisely: do Einstein's Field equations admit solutions that can be interpreted as standing gravitational waves [4]? One can superimpose two electromagnetic waves since its underlying theory, electromagnetism is linear . For superposition of gravitational waves one encounters the non-linear nature of gravity.

It turns out that under certain conditions a spacetime, known as Gowdy spacetime, can be studied which represents a non-linear superposition of gravitational waves. We study a toy model which represents an expanding universe filled with gravitational waves which are interacting and forming standing gravitational waves. The geometry of this 4-dimensional spacetime has spatial sections having a torus topology. This represents a 3-torus which is like a higher dimensional donut. Instead of joining the opposite sides of a square tile to form a 2-torus, you join the opposite sides of a cube in order to get a 3-torus. Figure 1 illustrates how standing waves can be studied in a 2-torus configuration. The basic idea we pursue is to have a family of observers immersed in a spacetime whose spatial geometry is of a 3-torus and try to understand how freely-falling test masses would behave.

When one is reading this article on a screen there exists three directions, one 'longitudinal' and two 'transverse'. Longitudinal is the direction towards or away from the screen (say Z-axis) and transverse is a direction parallel to the screen (one on X-axis and one on Y-axis). Generally, when a gravitational wave is perpendicularly incident on a ring of particles they are deformed into an ellipse and return back to the original shape in the transverse direction. We analyze such behavior in our spacetime. We also see what will happen to a set of particles in the direction of the wave, i.e, in the longitudinal direction.

We study this situation in *polarised* T^3 *Gowdy spacetime* [3] which is a vacuum solution to Einstein field equations with just gravitational wa-

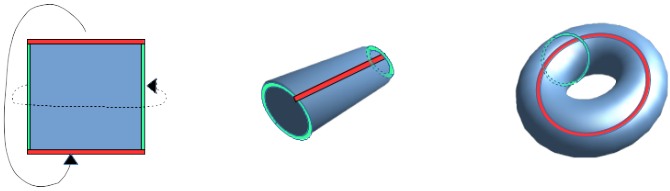


Figure 1: Sample of how to form a 2-torus. One can imagine a wave travelling in the azimuthal angle and interacting with itself to form a standing wave.

ves present. Each spacetime is characterized by a *metric* ds^2 containing the features of the spacetime and the corresponding metric functions reveal the nature of that particular spacetime. The metric we study has the form

$$ds^2 = e^f(-dt^2 + dz^2) + t(e^p dx^2 + e^{-p} dy^2) \tag{1}$$

Here the functions $f(t, z)$ and $p(t, z)$ are the metric functions. They are functions of time t and z is the direction of the wave. Their form is of $...sin(t)cos(z)..$ which represents a standing wave. And $0 \leqslant x, y < 2\pi$. We study a particular solution having the form:

$$\begin{aligned} p =& -\ln t + 2\beta\sqrt{\lambda} J_0(\frac{t}{\lambda}) \sin(\frac{z}{\lambda}) \,, \\ f =& \frac{\beta^2}{\lambda} t^2 \left[J_0^2(\frac{t}{\lambda}) + J_1^2(\frac{t}{\lambda}) - 2\frac{\lambda}{t} J_0(\frac{t}{\lambda}) J_1(\frac{t}{\lambda}) \sin^2(\frac{z}{\lambda}) \right] \\ & - 2\beta\sqrt{\lambda} J_0(\frac{t}{\lambda}) \sin(\frac{z}{\lambda}) \,, \end{aligned} \tag{2}$$

where J_0 is the Bessel function and β and λ are parameters. The periodicity of f and p implies $\lambda = 1/n$ with $n \in \mathbb{Z}$. The solution depends on parameters β and λ which control the amplitude and the number of gravitational waves in this spacetime respectively. The curvature singularity is at $t = 0$. After the big bang, this model expands anisotropically with just gravitational waves interacting and forming standing gravitational waves.

The main goal is to have a family of observers immersed in this spacetime who see how geodesics behave in this spacetime, specifically at the antinodes of the standing gravitational waves.

Behaviour of freely-falling test masses

The standing gravitational waves in our spacetime are in the Z direction. We found that in the direction of the wave the particles are attracted to the antinodes of the wave. One can imagine that as the amplitude of the wave is maximum at the antinodes it would imply a concentration of gravitational energy. This would imply a source of gravitational potential hence it should act as a region of attraction for particles. This is what we found in our spacetime particles are on average attracted to the antinodes. See Figure 2.

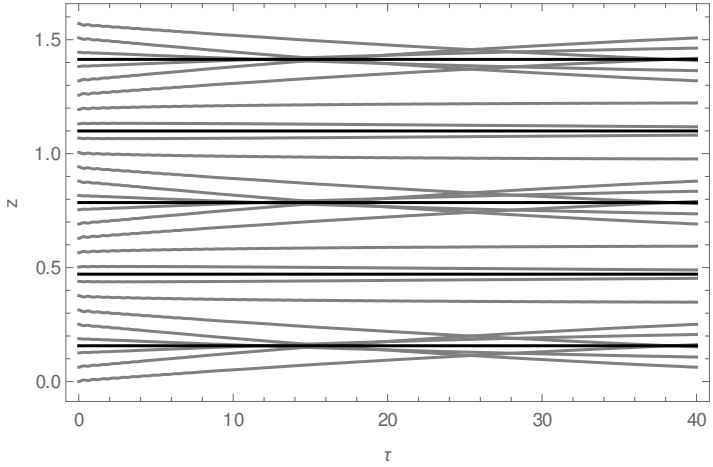


Figure 2: The behaviour of geodesics in 'Z' direction measured with respect to proper time τ – time which the observer measure with her/his own clock. We see attraction at the antinodes in the direction of the standing wave.

At these antinodes, we had freely-falling observers who try to analyze the behavior of standing gravitational waves in the transverse direction. Freely-falling observers are very important since they can use used to study the effect of gravitational waves without depending on the 'coordinate' effect of spacetime. For example, imagine if a person in a room is looking outside a window and observing a straight line. The person and the room are moving

very slowly in a wave-like motion(such that the person doesn't know it). The person might conclude that the line is moving like a wave but in reality, it's his whole frame of reference which is moving and not the line. Hence, one has to be careful while studying effects in general relativity and look for coordinate independent measurements. And this is done with the help of freely-falling observers(*orthonormal frame*). For our spacetime, the freely falling observer, at the anti-nodes, will observe a ring of test masses that is permanently deformed in the transverse direction. This permanent effect left behind after a gravitational wave has passed is known as gravitational wave memory. See Figure 3.

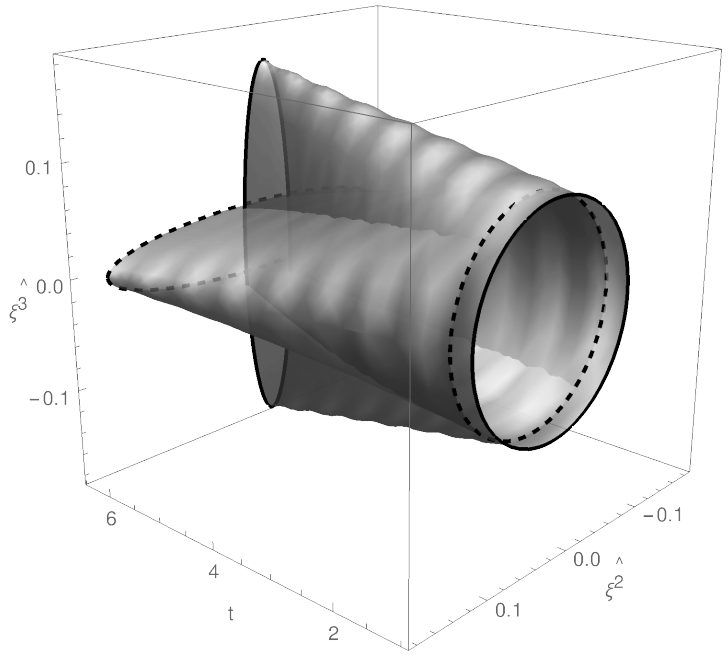


Figure 3: Behaviour of a ring of test masses in the transverse(XY) direction. The permanently deformed ellipse shows the presence of gravitational memory.

Conclusion

Till now around 50 gravitational wave detections have been made. The gravitational waves which are detected on Earth are of astrophysical origins. They are generated by compact objects (like Black Holes, and Neutrons Stars) very far away from Earth. As the detector is very far from the source, only the transverse nature of gravitational waves is detected. In principle, there exist longitudinal effects which are overshadowed since the compact objects are very far away.

The spacetime we study has just gravitational waves all around. So one can look for these additional effects of gravitational waves in our spacetime. In our work, we found that the longitudinal effect of the standing gravitational wave and a sphere of test masses in our spacetime will get squished into an ellipsoid in the direction of the wave. For the transverse direction, we found that a ring of test masses will be permanently deformed into an ellipse revealing the 'plus' polarisation present in this spacetime.

Although the spacetime we study is a toy model nevertheless this attraction of particles at the antinodes and the longitudinal effect indicate the non-linear effects one might expect when superimposing two gravitational waves [5]. A future investigation would be how an electromagnetic wave [2] couples to gravity and what would be the behavior of particles in that spacetime.

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(Im)possible puzzle

***Izabela Mandla**, Faculty of Mathematics and Computer Science, Jagiellonian University in Kraków, Poland*

Imagine the following set of circumstances: two prisoners have the opportunity to be released from jail, but only if they can solve a strange puzzle. At first glance, it appears to be very similar to many logic games, but upon closer look, it may seem as impossible to solve.

Introduction

How does this puzzle look? On the table is an 8x8 chessboard with coins instead of counters. There is one coin in each square, and it can be heads or tails. So we can have 32 heads on board as well as 11 or 0. The guard and the first prisoner enter the room containing the chessboard. The guard is carrying a small key, so small that it can be hidden under one coin and be impossible to spot. He had to pick one location to hide it. The first prisoner was looking for all of that procedure, and his assignment was to flip exactly one coin. The second prisoner arrives, and he must now guess where the key is hidden. The prisoners are unable to communicate. The only way to determine the location is through the arrangement on board. But would that even be possible?

We can assume that the prisoners were aware of the puzzle's rules and had time to plan a common strategy for that game, but they didn't know how the coin arrangement on the board would look like. Furthermore, the guard could listen while they planned their strategy, so if they make a poor choice, their chances of winning are extremely low. As a result, the prisoners' plan must be both universal and precise. The best option would be to find a way to be able to point to exactly one squere, regardless of which of the 64 it is.

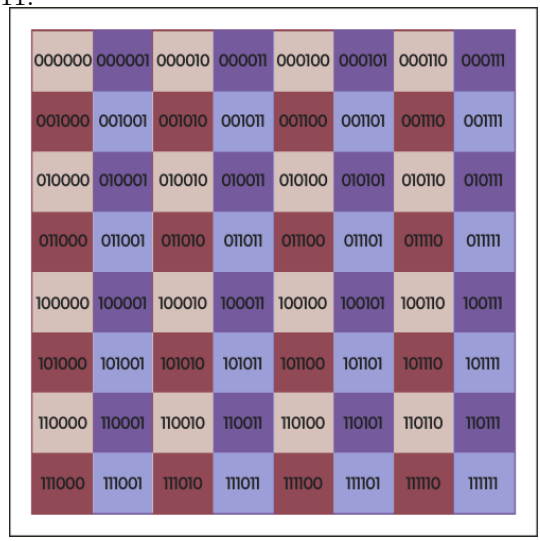
Solution

Counting every squere might be a good idea from the start. So let's do it in binary, starting with number 000000. The second number will be 000001, the third will be 000010, and so on. The final number would be 111111. As a result we can assign a six-digit number to the place where key

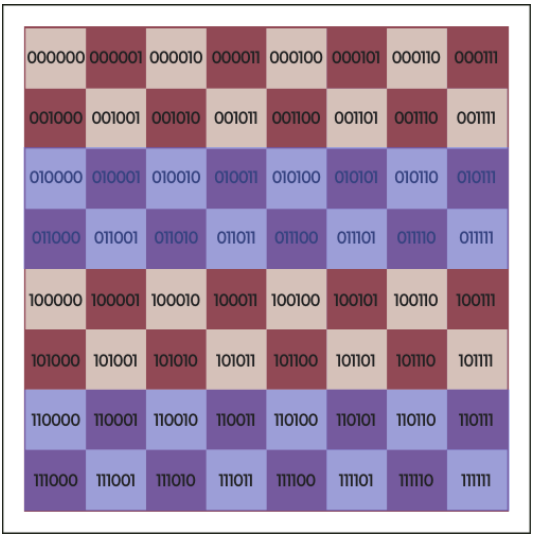
is hidden. Okay, but what can you do with that? Let's see if there is a way to somehow display that number on the board.

So the idea is to try to count if the number of coins that flip on the same side in a chosen area is odd or even. If it is even, we will write to a specific place in our binary numeb 0 and if odd, 1. That way, we will want to choose 6 areas that will show where the key is.

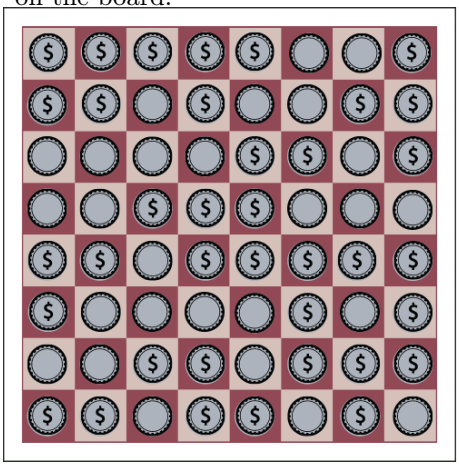
Let's see how it works. For our first area, we will choose all those squeres that have 1 in the first position of their number. So it would be 000001 as well as 001011.

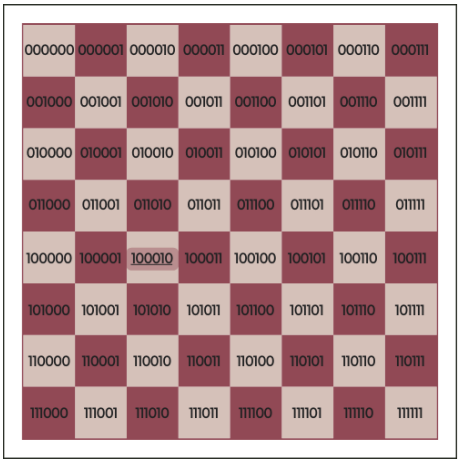


The second area would contain squeres with 1 in the second position, for example, 000010, 111010. And like that, we will get six areas. So, in the 5th area would be places with the numbers 111111 or 110000.



So what now? Let's try to figure out how to find out that the key is on squere with the number 110010. We will take a random coin arrangement on the board:

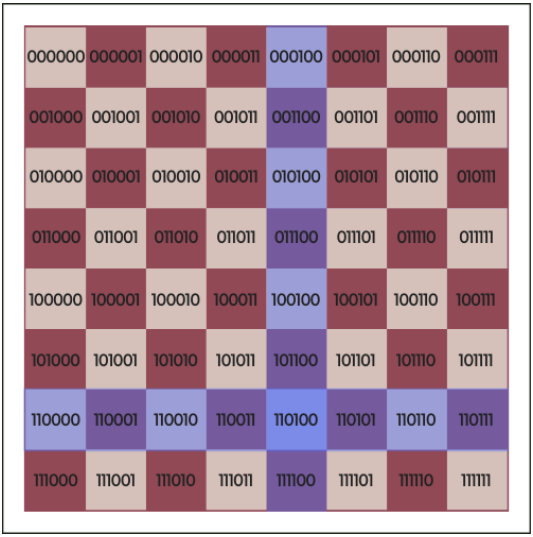




Let's check what is happening in the first area. We have an even number of heads, and the key's squere number is zero, so nothing needs to be changed. In the second area, the situation is quite similar. We have an odd number of heads, and the second figure in our number is one. What about the third one? Here something does not work. What does that mean? Our

flipped coin should be chosen from that area. But still, we have to remember that it can not be changed in the first two areas. It leads to knowing what the column where that coin lies.

We can do the same thing with rows. By repeating this procedure for areas 4th, 5th, and 6th, we will get the exact row which we should choose and, by combining it with the previous result, we get exactly one spot where we should flip the coin to obtain the number of the square where the key is hidden.



Conclusions and Extensions

This system works every time and gives a uniquely determined answer as to which coin we should flip. However, this is not the only one that will work.

One might wonder if that puzzle will work on other chessboards. It is not an accident that we have chosen the number of squeres that is equal to 2 raised to n-power. This is due to the fact that this situation is analogous to colouring the corners of a k-dimensional cube k different colors, where k is the number of squeres on the board. From that, it is possible to deduce that only the case with raising 2 will work.

Similar reasoning that was shown above could be used to understand one of the most basic correcton codes, the Hamming codes. They were invented

by Richard Hamming at the turn of the 40s and 50s of the last century. He intended to improve the computers on which he was working. His invention began this area of computer studies and unquestionably had an enormous impact on currently used machines. Looking from that point of view to that puzzle, we can see that it can also help to understand something crucial for computer science development and is not only interesting trivia.

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Sars-CoV-2 infection in light of circadian clock

***Joanna Doliwa**, Faculty of Biology, Jagiellonian University, Kraków, Poland*

Circadian clock is an endogenous biochemical oscillator that cycles with a stable phase, is synchronised by solar light, and runs with a period of approximately 24 hours. It is known to play an important role in regulating various aspects of viral infections such as viral replication and host responses. Standing in the midst of the COVID-19 pandemic, one may wonder what the specific interplays between the SARS-CoV-2 infection and the human circadian clock are. Here I review the role of circadian clock proteins in SARS-CoV-2 entry and replication, as well as the possibility of perturbation of host circadian rhythms due to the infection. Based on this information, I evaluate possible candidates for antiviral drugs. I then look at how timing of SARS-CoV-2 vaccination and drug dosing may affect their efficacy. Finally, I explain the effect of circadian disruption, which affects for example night shift workers, on the severity of developed COVID-19 symptoms.

Introduction

Circadian clock is an endogenous biochemical oscillator that cycles with a stable phase, is synchronised by solar light, and runs with a period of approximately 24 hours. Examples of its regulation include daily sleep-wake rhythmic pattern as well as olfactory sensitivity and repeated patterns of food craving at certain points the day. The circadian clock is also known to play an important role in regulating various aspects of viral infections such as viral replication and host responses [17]. In this article I would like to review what the specific interplays between the SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) infection and the human circadian clock are, and how the knowledge of them might contribute to improving therapeutic strategies against COVID-19 (Coronavirus Disease 2019).

Viral entry and replication

The first interaction occurs at the point of viral entry into a host cell. The surface spike (S) protein on the surface of the virus binds to the host's cell membrane ACE 2 (angiotensin converting enzyme 2) receptor. Another segment of the S protein contains a membrane fusion peptide, whose reactivity is promoted by cleavage of the S protein by TMPRSS2 (transmembrane

serine protease 2). This in turn causes SARS-CoV-2 to enter the cell and use its machinery to replicate [10], [20]. The promoter for the gene of the ACE2 receptor also encodes a binding site for the BMAL1-CLOCK dimer [4]. Bmal1 is one of the core clock genes and it encodes BMAL1 transcription factor protein. Although at a molecular level the circadian clock is built of several core clock genes that activate or suppress downstream targets through rhythms in transcription and translation, only Bmal 1 has been found to cause circadian arrhythmia in humans solely on the bases of its deletion. Hence, it is often used as a model for circadian research. The BMAL1-CLOCK heterodimer constitutes a crucial part of the mammalian circadian feedback loop, acting as a transcription factor by binding to a specific DNA sequence, which induces the transcription of other essential circadian clock genes. Above considered, it is speculated that the the binding of the virus unables the binding of the dimer, causing circadian disruption. Consistently with that the knockout of Bmal1 has been found to be associated with increased abundance of proteins regulating translation, protein folding, and intracellular vesicle trafficking which are the cell machinery used for viral replication [6].Furthermore, the loss of Bmal1 in key cell types studied across different viruses resulted in increased disease severity ([15], [8],[19], [5],[7], [13], [16], [22]).

Perturbation of host's circadian rhythms

It has been shown that the SARS-CoV-2 infection disrupts several physiological processes such as macrophage function, platelet degranulation related to host immune response [1]. Many of theses are circadian-regulated which makes us speculate that the infection may disrupt the clock function in infected cells and cause desynchrony with the surrounding tissue [17]. Studies on the IAV (Influenza A virus) also showed differences in peak expression times for core clock genes in the lungs of infected mice [18]. That is the time when the most circadian clock proteins are assembled has been shifted due to a viral infection, which implies that such infection likely causes perturbation of our daily rhythms. Interestingly however, as [9] point out the changes in circadian rhythms should also be evaluated as possibly being an adaptation to an illness instead of constituting a symptom of degeneration.

Chronomedication

It is now becoming widely recognised that immune function is regulated rhythmically, and that it is sensitive to the time of pathogen exposure (reviewed in [2]). Immune cells such as neutrophils, resident macrophages and monocytes as well as cells of lung epithelium exhibit diurnal patterns in responsiveness to infection [17]. Circadian clock therefore needs to be taken into account while administering antiviral drugs and medication since the inflammatory rhythms and possible changes in them during an active infection may translate to therapeutic strategies. Drugs with short half-lives (6h or less) are more sensitive to time of day administration [14]. These includes dexamethasone. This assumption is supported by the fact that the administration of prednisolone, a glucocorticoid-like dexamethasone, a pharmaceutical considered for becoming an antiviral drug for COVID-19, showed a time-of-day-dependent effect in alleviating rheumatoid arthritis symptoms [3]. On the other hand, drugs with a half-live longer than 24h hours like remdevisir, another candidate, are not prone to benefit from time-of day administration. Interestingly, diagnostic biomarkers enabling to determine the circadian phase of a test subject from a single patient already exist which may prove useful while determining the time of drug administration [21]. What is interesting, the recent mapping of the SARS-CoV-2 interactome identified 66 druggable factors, and 30 percent of these genes exhibit circadian oscillation, which points us to the direction of searching for antiviral drug candidates from within the clock-proteins' stabilising agents. The topic of chronomedication may serve as another example of a contact point between the circadian clock and viral infections. Apart from already mentioned 'clocking the drug' strategy, that is administering the drug in the right time, other examples include modulating disease outcomes as well as to incorporating lifestyle interventions to improve circadian function [17].

Vaccination and the impact of lifestyle

The above measures have considered viral disease treatment, however it is better to prevent diseases instead of treating them. Vaccines, for example the influenza one, have shown to exhibit greater efficacy when administered in the morning, which was measured by alleviated antibody response (reviewed in [17]. Regular sleep after hepatitis A vaccination has also been reported to provide enhanced the antibody response [12], [11]. Hence, one of the measures to be implemented in healthcare systems might be to administer the

SARS-CoV-2 vaccine in the morning. As mentioned before, the SARS-CoV-2 infection has a potential to disrupt the human circadian rhythmicity. However, impaired circadian clock may also greatly contribute to greater severity of the COVID-19 disease symptoms. Shift work, old age, and irregular sleeping and eating habits disrupt the circadian clock (which constitutes a so-called "Social jetlag"), which then leads to an exaggerated immune response due to less robust immune function [14] and in consequence more severe COVID-19 symptoms. A concern that also has been raised is that negative impact of ICU conditions such as difficulties in maintaining a light-dark cycle and time-restricted feeding to sedated or septic patients may also play a role in worsening the disease outcome [9].

Concluding remarks

Chronobiology i.e. the study of biological rhythms, is a growing field of research which slowly makes its way into clinical medicine. The interplays between this domain and viral infections such as the one of SARS-CoV-2 are significant, and might be useful in drug discovery and design, treatment timing as well as in providing appropriate hospital environment. Hence, successful approach for treating viral infections may, and according to many should require the willingness for cooperation between scientist, and clinical practitioners and healthcare policy makers.

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