Periodiek

8 - Perio interview: Mariano

Those who have taken Calculus 1 or Chaos Theory this year might have seen a new face on the other side of the screen: Hildeberto Jardón Kojakhmetov. Originally from Mexico, he moved to the Netherlands in 2011 for his PhD. After spending 2 years at the University of Groningen as a post-doc, he was appointed as an assistant professor in May. We wanted to get to know him a bit more, so we decided to invite him for an interview.
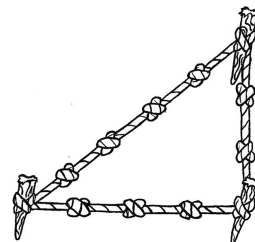
14 - 1st year university experience

What does university life look like in the eyes of a Dutch student? In this article, Tim van de Vendel answers a few questions about his latest experiences in life, giving an insight into what it is to be a Physics first-year student in the University of Groningen.

16 - Mathematics of Music

The rope you see on the right was used by Pythagoras to always have a device at hand to measure right angles. In the converse of his Theorem, the 3-4-5 triangle played a huge role, but could it simply have been ... played? As a musical instrument? Find out in this article about the interconnection between math and music!

In this Periodiek

From the Editor in Chief

With the new year approaching, I hope you all can look back on a satisfying 2022. In the weeks leading up to, during, and after, the summer break we have been hard at work to bring you the next issue of the Periodiek.

This issue of the Periodiek is also very different from what you are used to. We have switched from using InDesign to being completely in LaTeX. Tesse has done an incredible job recreating the layout the we are all used to. Going along with this change, we have also brought back the previous front page style.

As a closing of last academic year, we have Fotocie's top pick of pictures of last year, which you can find on page 12!

Robert Mol.

From the Board
Intern

AUTHOR: **A. QUINN**

Hi! For those who don't know me, I'm Aoibhin, Commissioner of Internal Affairs and resident dinosaur of the 64th board of the FMF! If you've been by the room recently you might've seen me running around like a madman, late to something or other, or in recent days cuddled up to one of our members for warmth. After years of pestering, I finally decided to join the board, albeit quite some time after the rest of my board were announced as kandies, and it's the best decision I've ever made. I'm so lucky to have Diana, Lorenzo, Maddy, Miranda and Balazs with me on this journey, and I couldn't have asked for a better, more wholesome team.

Even before I had a notion of applying for board, Intern was always the position that I thought would suit me. I love the community that we've built together as the FMF, and being able to share that with new members and watch them find their home here like I did so long ago makes my day brighter. There are definitely aspects of the position that I find uniquely challenging, as anyone who knows me well enough can attest to my usual state of disorganisation, but every day I've been learning and getting better at staying on top of everything and I think I'm starting to find a rhythm.

We've been board for just over a month now, and it has so far been an incredible, intense, chaotic and truly rewarding experience. For me, the beginning of the year has been the busiest, as I've been catching up with things that ideally would have started before the summer break, like getting all our committees up and running, and sorting out some personal chaos of my own. I am eternally grateful to all our active members for being so enthusiastic about committee work, and I'm especially impressed with all our new members who have dived headfirst into FMF life. I'm perhaps proudest of finally getting the KBE up and running again after several years of being grounded by lockdown. As I'm writing this, the committee are gearing up to announce their destination, and I think it's going to be a great one!

As we get into the swing of things this year, we're finally starting to have the breathing room to make our goals happen. One of mine is something I feel is super important for the association, and that is setting up a really robust, accessible platform for knowledge sharing. All kinds of knowledge, from standard committee information, to who you should talk to in the uni to get things done, to funny stories and FMF urban legends from times gone by. I'm fortunate that I have the support of the fantastic Comcie and Archie in this endeavour, and while this project is far bigger than my board year, I'm excited to get started and watch it grow. Watch this space!

Wishing you all a wonderful day, and lots of hugs,

Aoibhin Quinn •

Figure 1: Aoibhin Quinn.

Recipe
Irish Soda Bread

AUTHOR: **A. QUINN**

This is probably my favorite type of bread. Named for the baking soda that leavens it, it's fantastic served alongside a soup or stew, or just on its own spread with salted butter or jam. Don't worry about being super precise with amounts, when grannies make this they normally eyeball it.

Ingredients
- 4 cups (500g) of flour (If you want white bread, use white flour, for brown bread use about 3 parts brown flour to 1 part white flour)
- 1 Teaspoon (5g) of baking soda
- 1 Teaspoon (6g, or a big pinch) of salt
- 1 3/4 cups (420g) of buttermilk

For a vegan substitute: use soy milk or high protein plant-based milk and two teaspoons of lemon juice instead of buttermilk

Figure 2: Irish Soda Bread

Instruction
Preheat the oven to 220°C. Sift the flour, baking soda and salt into a large bowl and mix thoroughly. Add enough buttermilk to make a slightly sticky dough and mix until everything is just combined. Be careful not to overmix! Unlike with yeast breads, there is a limited amount of carbon dioxide you can get out of this bread, and once it's gone it's gone. Shape into a squished ball and place in a round cake tin (I normally put a piece of baking paper in the bottom of the cake tin). Cover the cake tin to keep in the steam and bake for 30 minutes, then remove the covering and bake for another 15 minutes. When the bread is done, the bottom will sound hollow when tapped. Cover the bread with a tea towel and sprinkle with water to keep it moist as it cools.

In the News
Another dose of science and engineering news

AUTHORS: **R. MONDEN, R. MODDERMAN**

Theoretical physics and astronomy are the fields that are dominating this "In the News", and for good reasons: fundamental problems in these areas are finally being solved!

All black holes have hair

Whenever physicists contradict each other in the most fundamental way possible, non-physicists simply ignore them and let them fight. Whenever a physicist resolves a huge conflict within the physics community, however, popcorn is grabbed to watch the show. Because, what if physics actually works? Astrophysicist prof. Xavier Calmet (University of Sussex) and his team claim to have solved the most fundamental problem in theoretical physics, which was posed by none else but Stephen Hawking half a century ago. Hawking stated, back in the 1970s, that Einstein's general theory of relativity on the one hand and quantum mechanics on the other hand contradict each other on the point of conservation of information. Back then, he pointed out that the theory that information entering a black hole will be lost forever contradicts a fundamental principle of quantum mechanics which states that the information that encodes a particle must always be conserved within the universe.
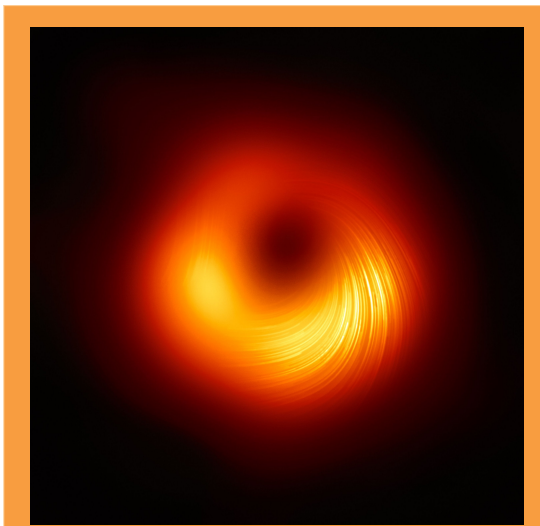

Figure 3: A black hole, more detailed then the picture one was used to

Calmet and his team's solution incorporates the concept of quantum hair. More classically, physical objects have been characterized by mass, charge, angular momentum, etc. but that's only the bare minimum to know if the object in question exists. With quantum hairs, they have found a mathematical construction in which particles entering the black hole will leave an imprint on the gravitational field of the black hole. In the form of quantum hairs. In a nutshell, Calmet et al have shown that black holes are in fact not bald but have hair and that precisely this construction allows for the two most fundamental theories in theoretical physics to not contradict each other.

Think logically, round stochastically

It is likely that you attended a primary school in your childhood where the education was based on one-way repetition, preparing for a job such as typewriter and assembly line worker. One thing you have definitely learned in primary school via brain deadening repetition is that numbers are always supposed to be rounded off to the nearest number with a given amount of significant digits. For instance, rounding off a price like $19.96 to the nearest dollar would always yield $20.

But what if I buy one hundred mangos in a grocery store each worth $0.96, and then want to calculate the total price because I don't like individual cents but only tens of dollars? To calculate the grand total I could round off the individual price first to $1.0 with two significant digits (let's say I'm bad with numbers, if that wasn't already clear), and then multiply that by one hundred to arrive at $100. Or, in correct physics notation with one significant digit, $1.0 \cdot 10^2$. But then I'm four dollars off, which is 4% of the grand total.

Instead, I could have stochastically rounded each of the one hundred of the individual prices. We could view $0.96 as an amount 60% "on the way up" to $1.0, and 40% "on the way down" to $0.90. Each time I add up a price (suppose I'm bad at multiplication but not at addition) I could decide with a probability of 60% to round up and with 40% to round down. The probability that I'd get an amount between $95 and $97

is $\sum_{k=50}^{70} \binom{100}{k} \cdot p^k \cdot (1-p)^{100-k}$, for $p = 0.6$, which is a probability of roughly 96.8%. The probability that we will be two dollars off is calculated similarly (for $k = 40$ to 80) and is roughly 99.998%. The probability to land at \$100 is $(0.6)^{100}$ which is roughly $6.5 \cdot 10^{-23}$.

What we just have avoided is the phenomenon of *rounding stagnation*. Primarily in quantum computing but also in machine learning, a lot of times many numbers have to be added on computers. Stochastic rounding has huge potential to solve these problems, as this new team of scientists are pleading for in their paper. Biggest drawback? Most computer systems don't have fast number generators. But this can be taken as an opportunity. Physics was the main motivation to invent calculus, so let machine learning, AI, etc. be the main motivation to invent better number generators. Oh yes, and let it be the motivation to ban the classical methods of rounding numbers in primary school.

Plants grown in lunar soil[1]

Since the first human landed on the Moon in 1969, scientists have learned a great deal about the lunar environment, attempting to answer questions such as: can we breathe on the Moon without a spacesuit (of course not), will future colonists to the Moon use the word *soccer* or *football* (*soccer*, of course!), and, can we grow crops in lunar soil? If you thought living on the Moon would be enough of a reason to avoid your veggies, bad news: turns out the latter is in fact possible!

In one of the first steps towards lunar farming, scientists have successfully managed to grow plants using soil collected during the Apollo 11, 12 and 17 missions. Although not all of the planted seeds successfully sprouted, the vast majority of them did.

The researchers also discovered that the location where the soil was collected had an impact on how well the seeds would grow, if at all. Seeds planted in soil less exposed to cosmic winds fared better than seeds planted in so-called *mature soil* — soil more heavily exposed to cosmic winds.

James Webb Space Telescope

The James Webb Space Telescope (JWST) has recently transmitted the first sharp photos. These days, you would expect it to be a selfie, but no! The pictures are of our very own solar system! This is not the first time that photos have been received from the telescope, however earlier pictures were of low quality.[2]

Figure 4: The launch of the JWST in December 2021. Source: jwst.nasa.gov

The JWST was launched in December last year using the Ariane 5 rocket, with the goal of becoming the primary astronomical observatory for the upcoming decade. Using the telescope allows astronomers to study events that took place through the history of our universe: from the Big Bang to the formation of the Earth. From the formation of our solar system to the invention of pizza.[3]

[1]https://www.sciencedaily.com/releases/2022/05/220512121840.htm
[2]https://nos.nl/artikel/2426910-ruimtetelescoop-james-webb-verstuurt-eerste-scherpe-foto-s-van-sterrenstelsel
[3]https://jwst.nasa.gov/content/about/index.html

Perio Interview: Mariano Méndez
Magician, researcher, teacher

AUTHORS: **L. ÁLVAREZ HEREDA, R. MONDEN**

Mariano Méndez is an astronomer and magic trick enthusiast, who teaches linear algebra and (multi-variable) calculus to students of physics, astronomy, computing science, and artificial intelligence. He is widely known for his fascination for magician abilities and incorporating them into his lectures. In this interview we will get to know him a little better.

What kind of research do you do?

I work in high energy astrophysics. High energy astrophysics is the study of particles with very short wavelengths. The energy of a particle is inversely proportional to the wavelength, meaning that highly energetic particles have very short wavelengths. Specifically, I study X-rays and the stars emitting them, such as in binary star systems. In binary star systems, one star orbits the other. Let us say that one of them is a black hole or, for example, a neutron star, and the other one a regular star. If the two objects are close enough, eventually the matter from the regular star flows to the neutron star or the black hole. Because of the angular momentum in the orbit, an accretion disk is formed around the star. This accretion disk then heats up and starts emitting X-rays.

What we then study is the X-ray emission from this disk or the material that is falling into the black hole, for example. Because the material making up the star is not homogeneous, the efflux of X-rays is variable. Sometimes there is more, sometimes there is less. The material falling into the black hole has gravitational potential energy, which is released as radiation. This radiation is something we can measure: think of the flux or the luminosity. Based on the data we measure, we then try to deduct what is happening physically, near the black hole for example.

Because X-rays do not enter the terrestrial atmosphere, we are forced to use satellites for observations. These satellites are designed for the detection X-rays within a specific range of wavelengths. Based on the information recorded using these satellites, we can estimate what, for example, the neutron star looks like.

We can also deduce how the material falls into the black hole. Because in the end, we cannot see objects such as black holes directly. We can observe the X-rays they emit, however black holes such as in Interstellar we simply never see. We thus have to deduce what they look like.

We have to understand these objects without having seen them directly.

Thus, we use models of an object for the purpose of studying their properties: how large are they and what is it exactly that emits X-rays? Of course, we could be wrong, since models are not perfect. Perhaps measurements we interpreted as one thing, might very well be something else.

Figure 5: Mariano Méndez. Source: rug.nl

What do you like most and least about the University of Groningen?

What I liked about the university, but what unfortunately has been changing, is that there was less of a focus on producing results. There was less of a need to produce results in order to advance in your career. Unfortunately this has been changing everywhere. Universities need money, they want to attract important scientists, they want to be competitive…

I feel that, these days, the pressure on a person to deliver results is too high: producing more and working to get more grants in order to do more research, having more PHD students, do more research and publishing continually. Fortunately I am no longer in a phase of my career where these things matter too much, however for young people these factors do play a role. They are under immense pressure, having to publish often and having to obtain grants continually. If they do not, then during some evaluation they could be told that they will be let go off.

This has been happening worldwide and unfortunately over the past ten years the University of Groningen has been moving in the same direction.

However, what I do like about the university is the connection with students. I worked in institutes where I did not have to teach. I did not like that quite much. Here the interaction with PHD and regular students is much better.

What do you like most about teaching?

When I was about your age I was fascinated by what I wanted to learn. The classes that I give are the first steps in students' academic careers. They are the steps that need to be taken before you can move on to more advanced topics. Linear algebra and calculus are not astronomy, but they are still a step that you need to take. I remember my enthusiasm from when I was young. I think that a great professor does more than just teach a course. That is why I try to talk about different subjects as well.

What kind of subjects exactly, well that depends. I've taught calculus and linear algebra to students from various disciplines, such as physics, astronomy and computing science. They are of course different kinds of students who are interested in different things.

Thus, what I like most about teaching is the interaction with students and, perhaps even, be a model to students, or something like that.

Nobody remembers the calculus, but the magic tricks always prevail.

How did you decide to incorporate magic tricks in the classes you teach?

When I started teaching linear algebra, it was the first time I used them in class. I used to give talks to the public at open days to students and they always included a very silly trick about how an object disappears in my hand.

To give an example: when I start talking about black holes, I hold a black ball in my hand representing the black hole and then I change hands, pretending to grab it and then proceed not to grab it. It works, because the mind follows the movement. If I move, you follow me with your eyes. If I move my hand while looking at it, you will also look at it. Thus, I can trick your mind into believing I put the ball in my other hand. For years this was the only trick I knew. I performed it during talks and people were dying of laughter. Then I realized it had an impact on the way they saw me. I am an astronomy professor, a serious scientist, but giving a talk like this gave me something to distinguish myself. And that was ten years ago.

I started to study magic using books and since I had both time and a deck of cards. The techniques I learned I then started to use in my talks. When I started teaching, I quickly realized that people's attention span is usually no more than 15 to 20 minutes. During topics that were very difficult conceptually, this proved to be a bit of a challenge, since it is more difficult for students to follow what is being said. Spending 45 minutes watching how something is explained on the blackboard is not very effective. I can talk for fifty minutes, but people are only going to listen for the first ten. Once they're lost, they're lost.

So I started thinking: if I could do something to generate a moment of relaxation. Classes start with tension, then fifteen minutes of relaxation and then once more tension. That is when I decided to schedule a short break after fifteen minutes of class. Just a very short break, however, since otherwise the students would leave and take fifteen minutes to return to their seats. Instead, I try to do something special so they stay seated, but do not have to think.

The reactions were always very positive. I enjoy responses such as 'huh' or 'what did he do?' when doing a trick. Of course, during online classes I could not hear the students' responses directly, but many students still expressed their surprise, albeit using the chat. In physical classes it is excellent. Nobody remembers the calculus, but the magic tricks always prevail.

What is your favorite magic trick?
I have several favourites, but the ones I like the most are those that predict the future. There is one in which I start talking about free will, whether it exists or not, whether a person is free when making decisions or is somehow influenced; and as I speak, there is an untouched pack of cards on the table.

Depending on what the students are doing, I focus the explanation of different things. If it is physics, I talk about how all the particles in the universe are governed by the same equation (very difficult but it still exists), and how if it is applied, we could be able to predict what would happen in the future. To artificial intelligence or computing science students, I show them an experiment in which you decisions can be predicted, before you consciously take them, using an MRI machine.

As I speak, the cards are still on the table. Then, I pick someone to choose a card. Once I made sure, there decision was final, I open the package, I spread out all the cards. All of them are faced down, except for one, which is facing up, and turns out to be the one that the student had chosen. There is obviously some trick behind this, but I won't explain it.

All these tricks, play with our concept of free will and existence, and that is what I like about them. I explain the scientific context, but the magic tricks still lead to some interesting philosophical questions. After all, do I decide what I am doing or is everything already determined from the moment the Big Bang started?

What is your favorite equation?
Although I never use it and cannot write it down, I find Einstein's equation relating the structure of space with energy and mass very nice. The reason is that it is very compact and the more compact an equation is, the better. Another equation I like very much is $E = mc^2$.

Equations that look simple, but are in fact very complex, are the prettiest.

What did you have for breakfast today?
A latte macchiato with two wholemeal toasts, one with butter and cheese, and another one with jam and sliced cured cheese. A mix between salty and sweet, along with a freshly squeezed orange juice.

What music do you listen to?
I grew up with Pink Floyd and the Beatles, although they preceded my sense of music, I also liked them very much. They were no longer together when I started to like them. The soundtrack of the first Blade Runner movie is also one of my favorites. It belonged to a Greek musician, Vangelis, who made electronic music for many films, and wrote the soundtrack for this one. The music for the sequel is not his, but it is very similar. And it helps me to sleep a lot. I put on Spotify and I program it to turn off in an hour and I fall asleep.

I like classical music, romantic music from the end of the 19th century. It is a sin to say that I don't like Bach, the baroque and the music of the middle ages; but despite its perfection it doesn't call me. I also like Italian opera, such as Verdi.

What is your favorite book?
Depends on whether it's fiction or not. As for non-fiction, there is a very interesting book I sometimes mention during my classes. The book is called *Gödel, Escher and Bach: An Eternal Golden Braid*. An excellent book, as is the author. Another non-fiction book I like is *Thinking Fast and Slow*,

I haven't read fiction in a long time, but I really like *The 100 Year Old Man Who Climbed out of the Window and Disappeared*. It is the story of a 100 year-old man who lives in a residence with a boring life. One day he escapes through the window and begins to live adventures, recounting his whole life since he was young. He meets many famous people and recounts how he had been a spy for the Russians and Germans. A good story which was very popular a few years ago. It was also adapted to a movie. I mention it since it was one of the last pieces of fiction I read.

When I was young, I really liked *The Illustrated Man* by Ray Bradbury, but these days I do not like it as much anymore.

How did you end up in Groningen?
When I first came to the Netherlands I worked as a postdoc in Amsterdam for four years. Then I worked at an astronomical instute in Utrecht, the *National Institute for Space Research*, which now no longer exists. At that time my wife was working in Munich, but she got a job in Groningen. We ended up moving to Zwolle,

which is conveniently located between Groningen and Utrecht. However, when we had a son things got more complicated, because we did not know where to leave him during working days, since we both worked and lived in different cities.

Later, which is now almost fifteen years ago, they offered me to work here and so I came, but before that I had worked almost seven years in Utrecht. The University of Groningen seemed interesting to me, a place where I could work and focus on what I was doing without worrying about performing or achieving at such a competitive level. In life one needs to work and dedicate oneself to things that make an impact, however there are also other aspects that need to be developed.

During the pandemic I worked from 9am to 11pm, only stopping to eat. Although I wanted to work on my own research, I did not have the time. And that's when I realized that the race is important, but life is life. Here in Groningen it was easy to balance my professional and personal life.

And that's when I realized that the race is important, but life is life.

What were some of the most notable cultural differences you encountered when moving from Argentina to the Netherlands?
I moved here 25 years ago and I found that many things were different compared to Argentina or other Latin countries. Here you have to have an appointment to visit friends and I can't just go visit them spontaneously. In Argentina the doorbell could ring at any time. Here, when I arrived they told me to be careful never to visit anyone at lunch or dinner time because it might be uncomfortable. In Latin America, if we were about to have dinner they just put another plate on the table and they divided the food a little more.

Also, the climate and population density are very different. I lived in Amsterdam and it was all very small (houses, stairs and rooms), without large patches of empty land or landscapes. The language also took a long time to learn.

Is there anything else you wish to mention?
Sometimes in class, during one of the breaks, I ask the students what they are doing, why they are in class that day, why they are studying and why in Groningen.

Many students do not know what I mean, because most of the time they do not stop to think about the reasons for doing things. They say that they are in this class because they want to pass the course and doing the homework to get a grade and get through the course. But that is not the *why* I am referring to. That is just a step to get to what you would like to do. But it is not an answer to *why* but rather to *what for*. The *why* is the ultimate motivation, the *for* is a means to that end.

At some point it is good to take a step back and look at yourself from a fresh perspective. Once you know what you are doing, you will know what motivates you. There is a psychologist who wrote a list of motivations by which people are guided: Maslow's *Hierarchy of Needs*. Based on that, I ask what motivates them. I cannot answer that question for them. The sooner they figure out the answer, the better.

Another question is: what is your position in society? Within five or ten years, many students will be leaders: CEO of a company or professor at a university. In general, university students are the most precious thing in society. The *icing on the cake*. And although it may not seem like it, they have a great impact. You need a certain level to get here. And the question is: what are you going to do for society? What legacy will you leave behind?

Do not wait for someone to give you the opportunity to do something new. Look for it yourself. The people behind Microsoft and Google did not ask for permission. The opportunity to change society comes from within. Not from someone else handing it to you.

Fotocie: A year in fotos

We picked some of our favorite photos of the year, taken and edited by our brilliant fotocie members: **Naomi Raspe, Esther van der Meer, Krzystof Pudowski, Ruxi Nastase, Matei Stoica and Tesse Tiemens.** We would like to thank them for their hard work and all our members for coming to activities and being their photogenic selves. We hope to see (and photogaph) you again next year!

Cheers, Fotocie.

1st year university experience
How is life?

AUTHOR: **T. VAN DE VENDEL**

Tim van de Vendel was a first year student, who after almost an entire academic year studying and living in Groningen, has some interesting things to tell. Here, he shares his own perspective on what is it to be a Dutch freshman, and how he has managed to get where he is now.

Who are you and what do you do?

My name is Tim van de Vendel, I'm 18 years old and in the process of finishing my first year of the physics bachelor. I'm originally from a small town near Nijmegen, about 2 hours straight south from here. Since I moved here, I joined Gyas, started writing for Ukrant and became chair of the PIENTER-committee. Above all of course, I'm a proud FMF'er.

Figure 6: Tim van de Vendel

How did you end up here and studying Physics?

I started broad when considering what to study. I loved physics of course, but I didn't want to jump to conclusions. I thought of studying Dutch, classics, journalism, nanobiology and at some point even music school. After a lot of open days, I decided I was most passionate about STEM and wanted to end up there. I considered dozens of engineering programmes, but I always arrived at the same conclusion: there's not enough physics and mathematics in this programme. That meant my last option was to just study 'pure' physics. Groningen isn't a very logical choice for me distance-wise. I got here through the process of elimination. Nijmegen was too close, Amsterdam too expensive and Utrecht not interesting enough. The final choice between Leiden and Groningen was a tough one, but of course: *er gaat niets boven Groningen*.

What motivated you to study here?

I didn't know much about Groningen when I chose to study here. The programme structure and quality of education were the main reasons I ended up here. Apart from that, I heard great things about the student life here, and that is how Groningen finally won me over.

Did you make the right decision?

100% . I think it's normal to have doubts, and of course I've had those over the past few months. But I have never regretted my decision. I'm extremely happy with how I've been able to develop myself over the year that I've been here so far.

How involved are you in uni life?

As much as possible. When I came here, I forced myself to actively dive into university life, because I knew there was a great risk that I'd just lock myself in my room to study all day. That's why I joined Gyas, applied for Ukrant, I'm doing Honours and I've been in four committees over the last year. Those things gave me the chance to develop myself besides my study and I don't regret any of it.

Was it difficult to adapt to living on your own?

Honestly, I expected worse. My mother would probably cry at the sight of my room right now and I called her out of panic more than I'd like to admit, but I feel like I have finally settled. It's actually quite nice to be able to do everything by yourself, it gives me complete control

over what I want to do and when I want to do it. That has gone wrong quite often, but those instances were also very good lessons.

How has covid affected your life so far?

Of course, I, as everyone, was affected by covid. My introduction week wasn't in-person, I went to my first physical lecture in the last block and going out wasn't really an option for a long time. Still, it would feel wrong to complain. The first-years from last year and some of my fellow first-years now had it much worse than I had. I lived by *improvise, adapt, overcome* throughout the covid-period. House parties instead of going out, online study sessions instead of going to a tutorial and late night gaming instead of playing board games. I ended up becoming a much more inventive person, and due to covid I can better appreciate the freedoms I have now. But I'm glad it's over.

How were your first months here?

Stressful, scary and unforgettable. I learnt more in those few months than in the entire year before that and really surprised myself at some times. Suddenly I had to cook, do the dishes, clean, shop for groceries next to my usual studying, sporting and relaxing. It took some planning, but I managed. Apart from that, I met a lot of very inspiring new people and got to explore my academic, sport-related and alcohol limits. For the first time in my life, I could fully choose how to express myself and actually be myself. The whole thing felt like one big rush. It has slowed down now, but I can confidently say those were the best months of my life.

Any difficulties?

Of course, but you can only learn from your mistakes. I discovered that fungus can spread quite quickly, my room indeed doesn't clean itself (thanks mum), how a washing machine works and that apparently you need to put the trash out sometimes. It has been going better since.

What is your experience in such an international environment?

I had never been in an international environment before. I didn't need to worry about my English, but I had never really worked or lived with other cultures. I really noticed cultural differences during my group assignments or even when just hanging out. Everyone has their own culture, which makes it a wonderful learning experience on how you can look at the world. It has brought me more wisdom than expected, and I'm very glad I chose to study in an international environment.

Do you see yourself here in 5 years?

Not necessarily in Groningen. I started my bachelor with an open mind about what to do after. I definitely want to spend part of my studies abroad, perhaps a minor or a master. After my master's? Not a clue. Academia, education, journalism and all the other options that you hear about all sound equally attractive. Most importantly, I don't want to stay in Groningen for the rest of my life, but I haven't yet considered where I want to go instead. We'll see.

What is your advice for the next batch of first-years?

Enjoy your new adventure here! Don't be scared that you're not going to meet anyone. Everyone shares that fear when they arrive, but it's gone pretty soon after in my experience. Join a student- or study association (at the least FMF), put in work for a committee and go to activities, then you'll find your place quicker than you can imagine. Don't forget to take your time for yourself every once in a while. But most importantly: enjoy!

Mathematics of Music
(Pseudo-)Mathematics behind harmony of music

AUTHOR: **R. MODDERMAN**

Start with the triple $(3, 4, 5)$. Now, close your eyes and keep this integer triple in mind. What else has come to your mind? A right-angled triangle with side lengths 3, 4 and 5? Drawn on a piece of papyrus? Residing on the working table owned by nobody else but the great Ionian Greek philosopher Pythagoras?

Pythagoras's triangles, ropes, and strings

If such imagery comes to mind, then I'm in fact not surprised. Most people, and especially physicists and mathematicians, would recognize $(3, 4, 5)$ as the side lengths of the most elementary right-angled triangle with integer side lengths. The identity $3^2 + 4^2 = 5^2$ is an example of the law of Pythagoras, which states that in a right-angled triangle the sum of the squares of the lengths of the two shortest sides equals the square of the length of the longest side. The converse is also true - whenever you have a triangle of side lengths a, b, c satisfying $a^2 + b^2 = c^2$, then the angle between the sides with lengths a and b is a right one! Undoubtedly, Pythagoras was aware of this - most likely, he used the converse of his Theorem to come up with a rope of 12 equally spaced knots to always have a tool at hand to measure right angles.
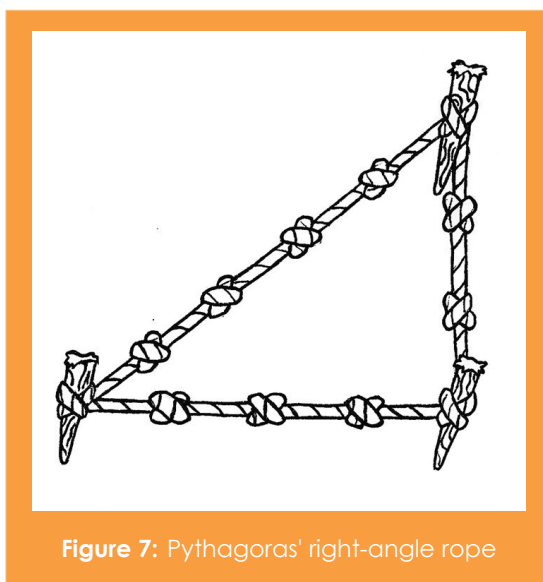

Figure 7: Pythagoras' right-angle rope

But now. We all know that Pythagoras was very curious and inventive. What if upon constructing his 12 knots rope he used a string that you could play to hear a tone. You would get three strings at the lengths of, say, 30, 40 and 50 cm, if the knot spacing is 10 cm. What would you hear if you would play all three sides at once? You would hear three tones, for sure, but do you actually get something coherent? Or will it sound like a bunch of false notes? The answer is that you'll hear the perfect minor triad, which is the chord almost half of the songs that have ever been written start with![4] If Pythagoras would actually have played his $(3, 4, 5)$-triangle, then that must definitely have been his inspiration to become the founder of modern Western music theory (likely he hasn't pre-written famous Led Zeppelin songs, though).

The divinity of the rational numbers

So, how did Pythagoras tune his string? First off, he noticed that if he would take a random string, play it, then fixate exactly one half of the string so that only one half of the string vibrates and then play that part, the second note sounds exactly the same but then higher. This *interval*[5] is called an *octave* and most musicians don't really distinguish between these notes as they appear to have the exact same flavour. Taking two identical strings, playing both at the same time whilst playing only half of one of them would yield two tones in a perfect $2 : 1$ harmony: the shorter string vibrating would vibrate at a frequency precisely two times of that of the longer string. Since this is the most fundamental harmony in music, by far most musicians (even the most experimental) do not fundamentally distinguish between notes separated by an octave. On the piano for instance, any two keys that "look like each other", for example two white keys right before a group of two black ones, are separated by an octave.

Mathematically speaking, all that happens when musicians don't really distinguish between notes that are separated by an octave is that an *equivalence relation* is constructed on the set of all playable notes. On the

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[4] An example of a song that starts with the A minor triad would be Led Zeppelin's "Stairway to Heaven"
[5] An interval in music theory is simply two notes, either played simultaneously or after one another

piano for instance, this is done by giving labels to these equivalence classes. For instance, the class of all C-notes are all white keys right before a group of two black keys. Notes belonging to the same class sound so incredibly similar, that they deserved to be named the same and even look the same on a piano keyboard.

Figure 8: Piano key labeling (pianosecrets.com/piano-keyboard-diagram/)

Now, let us play the most fundamental chord in existence: the major C triad, which consists of a C, the first E above (or, equivalently, to the right of) that C, and the first G above that E.[6] If music according to Pythagoras is that rational, what would be the relative frequencies of these notes? Pythagoras would say, from lowest to highest, $4 : 5 : 6$. The separation between C and E is a major third, and the classical ratio of a major third interval is $4 : 5$ which is quite an elementary fraction. It is often said that this ratio sets the "mood" of the triad, whereas the ratio $3 : 2$ - that of the separation between C and G - sets the "foundation" of the triad.

Since the sound waves of (piano) strings are pretty well approximated by pure sine waves (ignoring the overtones, which is a completely different story), and assuming when we play the major C triad by hitting all three keys exactly simultaneously, we would get a sound wave whose amplitude $A(t)$ as a function of time would look like

$$A(t) = \sin(4t) + \sin(5t) + \sin(6t)$$

when ignoring units of time. All that matters for now is its shape. Plotting a superposition of waves like these can be done in an (A, t)-plot, but often it is better to plot a superposition of multiple waves as a *Lissajous curve*[7]. That is, for a chord consisting of n waves with frequencies $f_1, \ldots, f_n$ we do not plot $A(t) = \sum_{i=1}^{n} \sin(2\pi f_i t)$ but we plot the parametric curve

$$\mathbf{r}(t) = (\sin(2\pi f_1 t), \sin(2\pi f_2 t), \ldots \sin(2\pi f_n t))$$

in $\mathbb{R}^n$. Plotting for $n > 3$ does not really make sense (except for those prodigies who have the superpower to envision the fourth dimension and beyond), but plotting intervals ($n = 2$) and triads ($n = 3$) is perfectly fine!

Before we plot triads as three-dimensional curves, let us take a look at plotting intervals first. Fortunately, Wikipedia has already done that for us.
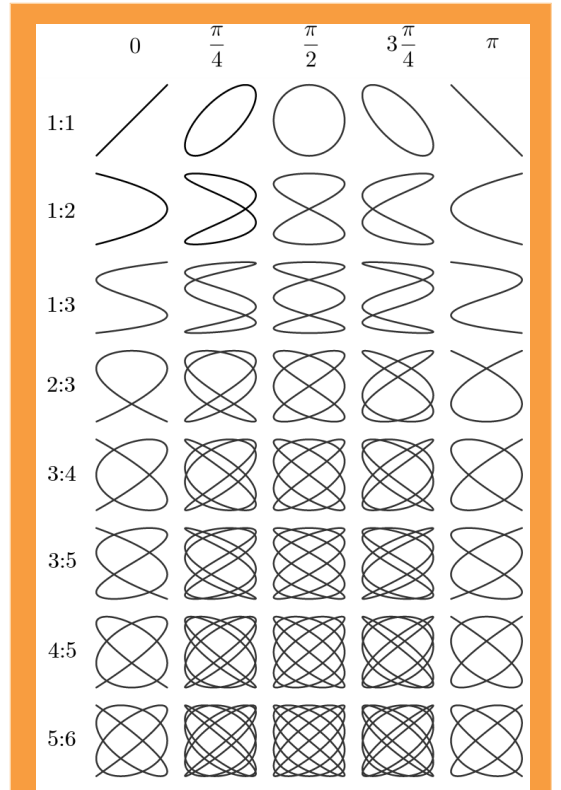

Figure 9: Lissajous curves for the most fundamental rational numbers (https://en.wikipedia.org/wiki/Lissajous_curve)

The first column of figure **??** is of particular interest, as it represents two-dimensional plots of intervals when hitting the two notes exactly at the same moment. The other columns represent those situations in which the instances of maximal pressure (or amplitude) of the two notes or strings don't coincide. It should come as no surprise that the most fundamental ratio's are not only most pleasing to hear but also to see, in the form of a Lissajous curve.

Since it is possible, why not also plot a major C chord in $\mathbb{R}^3$ in the fashion of Lissajous, with (relative) frequencies $f_1 = 4$, $f_2 = 5$, and $f_3 = 6$:

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[6] An example of a song that starts with *this* chord is Alphaville's "Forever Young"

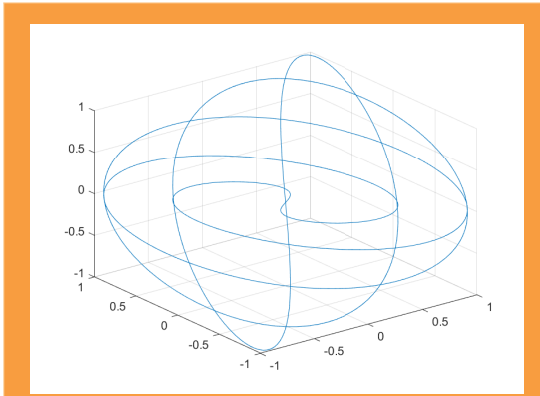[7] These curves are named after French physicist Jules Antoine Lissajous

Figure 10: Lissajous curve of major C triad

Beautiful, isn't it? The less complicated a superposition of waves, the more pleasing to the eye when plotted and the more pleasing to the ear when heard.

The trouble of Pythagoras's ideology

The two most fundamental Pythagorean ratio's 2 : 1 and 3 : 2 (the perfect fifth) gave rise to a *Pythagorean tuning* of the piano, which was achieved using the *circle of fifths*. An example of a fifth would be a C plus the first G to the right, and the name of fifth is justified by, if you start to walk from C to G along the white keys to the right, G will be the fifth note if you start counting at C. Another way to remember the separation between two tones constituting a fifth is by counting the *semi-tones* between them, and this number is always 7 for a fifth. Since the greatest common divisor of 7 and 12 is 1 - or, differently put, 7 modulo 12 is a unit in the ring $\mathbb{Z}/12\mathbb{Z}$ - one would have to repeat this procedure exactly 12 times to get back to a note in the same equivalence class.

Now we arrive at a problem. If we start at a C and go up 12 perfect fifths, we'd end up at a tone with a frequency a factor $(3/2)^{12} \approx 129.75$ higher. But since we've also travelled 7 octaves, this ratio is supposed to be $2^7 = 128$! Sure, those two numbers differ by less than 2%, but it is still noticeable especially in playing harmonic chords that doesn't sound that harmonic anymore if one plays in a scale other than C whilst still residing in a C-based Pythagorean tuning. This discrepancy is known as the *Pythagorean comma*[8]. Of course, in Pythagorean tuning one wanted to preserve the pure octaves, but since the tuning depended on a base tune and all ratio's where rational, fifths in other scales would be rational as well

yet would not be equal to 3 : 2.[9] For example, the interval composed of F# with the first C# to the right of it, which is a fifth as the separation is 7 semitones, would be a ratio of $2^{18}/3^{11} \approx 1.48$ which is *almost* equal to 3 : 2. So, what's the problem? The problem is that $2^{18}/3^{11}$ is a rational number very close to the much more fundamental ratio 3 : 2, and precisely these ratios sound the worst. At this point it would make more sense to include *irrational* ratios. It turns out that irrational ratios close to a very fundamental ratio sound much better than rational ratios close but not equal to a very fundamental ratio.

Equal temperament and the symmetry of music

Since the octave as most fundamental ratio is holy, not only in Pythagoras's time but even now, we still force any octave to have ratio 2 : 1. Instead of taking fundamental ratios we force any two consecutive keys (the semi-tone) on the piano to have equal separation $\sqrt[12]{2} \approx 1.059$. No interval will be rational, except for those that are separated by an integer number of octaves. A tuning like this is called *just tuning*, or *equal temperament*, and it is widely believed that in the order of half a millennium ago this tuning was invented at multiple places more or less independently. Its major advantage is that - unlike in Pythagorean tuning, when a root key is needed - playing music in any scale will sound good. The most well-known celebration of the invention and popular use of equal temperament in Europe was reflected through Johann Sebastian Bach's *Das wohltemperierte Klavier*[10], a collection of preludes and fugues in which each of the 12 major scales and each of the 12 minor scales are being used exactly once.

But why does music in this fashion still good? If you are not too much into the most wild forms of experimental music, then at least 99% of music you hear is based on equal temperament. Any perfect fifth, a separation of 7 semitones, would have a ratio of $(\sqrt[12]{2})^7 \approx 1.498$ in frequencies, standing very close to $3/2$. The interval C-F, which was based on the ratio 4 : 3, is separated by a ratio $(\sqrt[12]{2})^5 \approx 1.3348$, which is *almost* 4 : 3! The major third in this way, which is the interval separated by 4 semi-tones, becomes $(\sqrt[12]{2})^4 \approx 1.2599$ which is *almost* according to Pythagoras's perfect major triad 5 : 4.

Precisely this property of $\sqrt[12]{2}$ is responsible for music's versatility, reflecting the perfection of Pythagoras in an irrational way, and its slight imperfection in this approximation is what makes the harmony of music this fascinating and maybe even divine.

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[8] https://en.wikipedia.org/wiki/Pythagorean_comma

[9] This phenomenon is very well explained in https://www.youtube.com/watch?v=Yqa2Hbb_eIs, and the most horrible sounding triad is played at 1'22

[10] The official English name is "The Well-Tempered Clavier", as a means to express that the piano was tuned "well"

The Pegasus Project
Exchange article

AUTHOR: **L. VAN DIJK**

In this issue of the Periodiek, we have collaborated with the editors of the SIBylle, the magazine of SIB Groningen, the international oriented Dutch student association, also known as the Dutch United Nations Student Association (DUNSA) about a recent international investigative journalism initiative known as the Pegasus Project.

In the midst of the COVID-19 pandemic, a group of 80 journalists from 17 media organisations in 10 countries were working through a database of phone numbers, uncovering a wide array of human rights abuses. The 50,000 phone numbers on the list, leaked to Forbidden Stories and Amnesty International in 2020, were potential targets selected for surveillance by clients of Israeli based technology firm, NSO Group. The investigation and reporting that followed is called The Pegasus Project.

Given the size of the leaked database, Forbidden Stories invited 16 other media organisations to help, including The Guardian, Le Monde, Süddeutsche Zeitung, and the Washington Post. They were supported by Citizen Lab and Amnesty International's Security Lab, who performed forensic analysis on some of the phones.

While NSO Group claims that the Pegasus spyware is only used to "investigate terrorism and crime", the Pegasus Project found the list of potential targets included at least 180 journalists, 85 human rights activists, 7 former prime ministers, 3 sitting prime ministers, 3 sitting presidents, and a king.

In July 2021, they started publishing their findings. Amnesty International's Security Lab released a Forensic Methodology report, detailing the technical indicators of a Pegasus attack. The report stated the research "uncovered widespread, persistent, and ongoing unlawful surveillance and human rights abuses perpetrated using NSO Group's Pegasus spyware".

Forensic Investigation

From the 50,000 phone numbers contained in the data leak, over 1,000 owners were identified and 67 underwent forensic analysis. Despite NSO Group claiming that Pegasus "leaves no trace," 37 of the phones analysed showed signs of Pegasus activity and 23 were successfully infected. For the remaining 30, the test was inconclusive, half of these were Android, for which the system doesn't log the information needed to identify Pegasus activity. However, 3 Android phones did show signs of targeting, for example, Pegasus-linked SMS messages. These SMS messages carry malicious links, which when clicked on allow Pegasus to infect the phone. This tactic, known as phishing, was the method of choice for Pegasus from 2016 to 2018.

But if we don't click on suspicious messages we're safe, right? Unfortunately not. Pegasus has become increasingly more advanced, using zero-click attacks which require no interaction from the victim in order to infect the phone. Instead, these attacks exploit bugs in popular apps, such as iMessage, WhatsApp, and FaceTime.

By 2019, the majority of Pegasus infection attempts used zero-click attacks. Despite key vulnerabilities in iOS, specifically iMessage and FaceTime, being patched, the zero-click attacks can still be used to infect phones with the newest version of iOS (as of July 2021).

> *But if we don't click on suspicious messages we're safe, right? Unfortunately not.*

After being infected with Pegasus, the attacker has complete access to the device, its messages (including encrypted messaging apps, such as WhatsApp and Signal), emails, media, calls and contacts. The spyware can record live audio and video by turning on the microphone and camera, all without the user being aware.

At the beginning of 2021, Pegasus started to manipulate system databases and records on infected devices to hide its traces. One way it does this is by changing names of system files or spoofing iOS processes, making programs not usually visible to the user appear as legitimate Apple code. For example, a Pegasus process named "MobileSMSd" was used, spoofing "MobileSMS" the iOS version.

Although the spyware has become more advanced over the years, there was a time when NSO Group was not as good at hiding its traces. In 2016, researchers found references to "Pegasus" in the malware on an infected phone. Additionally, they were able to follow a trail in the network infrastructure back to the servers of NSO Group. NSO uses over 400 servers, predominantly hosted at data centres in Europe, with 212 servers in Germany, 79 in the UK and even 5 in the Netherlands. These servers appeared again in the analysis done over the past two years, confirming that NSO Group was involved in the attacks uncovered.

Impact

From journalists to royalty, the list reveals that the spyware is used for more nefarious purposes and not - as NSO Group claims - only for fighting terrorism and crime. Among the countries identified as having purchased Pegasus are Hungary, India, Mexico, Morocco, Saudi Arabia, and the United Arab Emirates - countries which don't have the best track record with human rights.
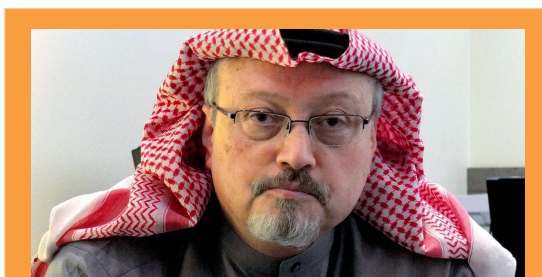

Figure 11: Jamal Kashoggi

Murdered Journalists: Jamal Kashoggi & Cecilo Pineda Jamal Kashoggi (above), a Saudi journalist in self-imposed exile after falling out with the royal family, was murdered on the 2nd of October, 2018. He went missing after entering the Saudi consulate in Istanbul to obtain documents to prove he was divorced, so he could marry his fiancée.

Both the phone numbers of Kashoggi's wife, Hanan Elatr, and fiancée, Hatice Cengiz, appeared in the leaked data. Elatr was repeatedly targeted from September 2017 to April 2018. Whereas, Cengiz was successfully infected by Pegasus four days after the murder.

Furthermore, Kashoggi's son and other family members in Saudi Arabia and the United Arab Emirates had been selected for targeting as well as three of his associates and two Turkish officers investigating his murder.

Cecilio Pineda, a Mexican journalist, appeared on the list two weeks before being killed in March 2017. He was at a carwash waiting for his pickup to be cleaned, laying in a hammock not visible from the street.

Hours before his murder, Pineda accused state police and local politicians of colluding with a violent local capo known as El Tequilero. He had told his mother that "if something happens to me, it will be the politicians." Statistics from the Mexican government suggest that over a third of attacks on journalists are perpetrated by public officials.

Despite being out of view from the street, Pineda's killers were able to locate him. His phone was never found, so forensic analysis could not be done to establish whether a Pegasus infection was even attempted. However, it is believed that Mexican state security has access to the spyware and given the close links between politicians and organised crime, there are concerns that this powerful technology is being sold or passed on to cartels.

Political Leaders: Emmanual Macron
Among the leaked data was the personal phone number of French president, Emmanuel Macron, along with the majority of his cabinet. Mediapart reported that the phones of five cabinet members showed signs of Pegasus activity. Investigations indicate it is likely that Morocco, a close diplomatic ally of France, was the NSO client interested in targeting Macron and his cabinet. Morocco strongly denied the use of Pegasus, saying it "categorically rejects and condemns these unfounded and false allegations".

The diplomatic fallout from the Pegasus Project not only affected the relations between France and Morocco, but also between France and Israel, who subsequently offered to ban future NSO clients from targeting French officials.

Figure 12: Princess Latifa

Royalty: Princess Latifa

In 2002, aged only 16, princess Latifa (above), daughter of Sheikh Mohammed bin Rashid al-Maktoum - the ruler of Dubai, attempted her first escape. She was caught and jailed in Dubai for over three years, where she says to have been kept in solitary confinement and tortured.

Latifa planned her next escape more carefully. Starting in 2011, she enlisted the help of her close friend and fitness instructor, as well as a former French spy who had successfully escaped Dubai. Late February 2018, the trio begin the second escape attempt. Eight days into the journey and just off the coast of India, the boat was boarded by Indian special forces, and Latifa was returned to Dubai.

How did the meticulously planned escape fail? A day after her escape started, Latifa's phone number appears in the leaked data. In the following days, the phone numbers of the princess' friends start appearing on the list. But, believing that their communications were secure, Latifa contacted friends and family to let them know she was safe.

Without the phones to carry out forensic analysis on, it cannot be established if the phones in question were successfully infected with Pegasus, and if this is how the princess was caught. However, the timing at which the numbers appear make it highly probable that it was attempted.

NSO Group terminated Dubai's contract, in part due to the surveillance of the family members of Sheikh Mohammed.

Responses

The global scale of the Pegasus Project's reporting has prompted responses from countries across the world. The US placed NSO Group on a blacklist. In India, the Supreme Court ordered an investigation into whether the government illegally spied on journalists, activists and political opponents using Pegasus. Mexican authorities made the first arrest linked to the Pegasus Project.

Israel, trying to distance itself from Pegasus, stated "NSO is a private company, it has nothing to do with the policies of the Israeli government". However, the Israeli government regulates the sale of the military grade spyware which NSO Group sells and has seen improved diplomatic ties with those countries to which Pegasus was sold. To deal with the fallout, the government set up a multi-agency task force.

NSO categorically denies that the leaked database has any relevance to the company. They claimed that the list "is not a list of targets or potential targets of Pegasus". Head of Amnesty International's Security Lab, Claudio Guarnieri, said that "there's no doubt in my mind that what we're looking at is Pegasus".

While the data indicates that the spyware was used to target criminals and national security threats, it also points to the widespread misuse of the technology. Agnès Callamard, Secretary General of Amnesty International, said "The Pegasus Project lays bare how NSO's spyware is a weapon of choice for repressive governments seeking to silence journalists, attack activists and crush dissent, placing countless lives in peril."**.**

Brainwork
Chessdoku

AUTHORS: **H. JAGER**, **R. MOL**

Our puzzle setters couldn't agree on what puzzle to put in the Perio, so they finally decided to put them all in at once. You will need to solve 3 puzzles at the same time.

The puzzles
The first puzzle is a 9x9 cage sudoku. In a cage sudoku, normal sudoku rules apply with an extra twist. You have to make sure the sum of numbers in each cage is equal to the number in the upper left corner of the cage. A number can't appear in the same cage twice.
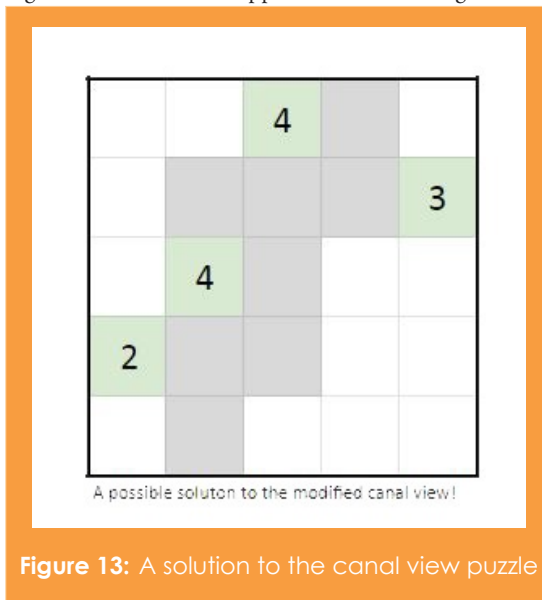

Figure 13: A solution to the canal view puzzle

The second puzzle is a modified canal view puzzle. Shade some cells to create a single connected group. Green squares can't be shaded, and indicate (with their sudoku number) the total amount of shaded cells connected vertically and horizontally to that square. Every shaded cell needs to be connected to at least one green square in this way. You cannot form a 2x2 'puddle' of shaded cells anywhere in the grid.

The third and final puzzle is a chessboard in a valid state (obtainable through a regular game of chess), using the sudoku grid without the bottom row and the rightmost column. Some chess pieces have been given. There are 13 additional pieces that still need to be placed (indicated with an *).
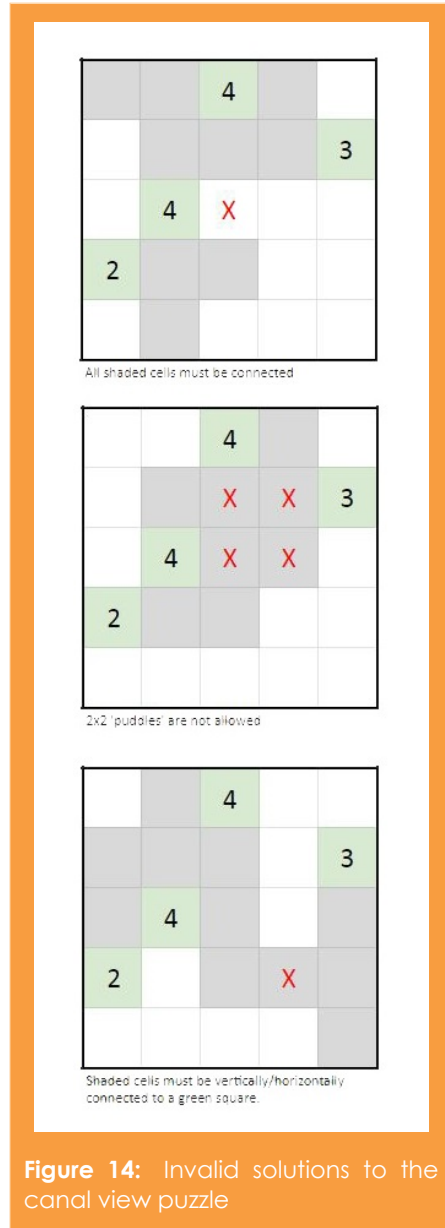

All shaded cells must be connected

2x2 'puddles' are not allowed

Shaded cells must be vertically/horizontally connected to a green square.

Figure 14: Invalid solutions to the canal view puzzle

Each chess piece corresponds to a sudoku number and vice versa, as follows:

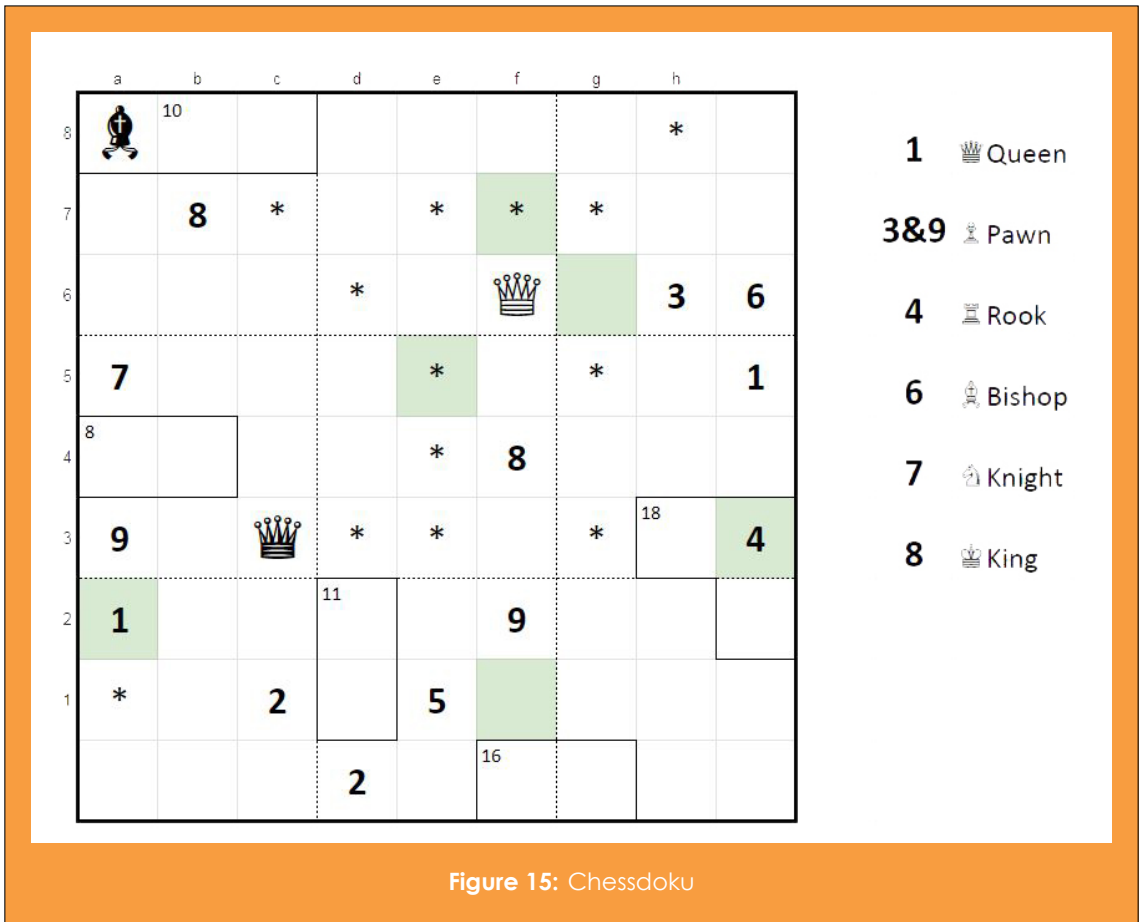|		
1 - Queen	3 & 9 - Pawn	4 - Rook
6 - Bishop	7 - Knight	8 - King

Figure 15: Chessdoku

Pieces in shaded cells (from the canal puzzle) are White while pieces in unshaded cells are Black. Please submit the following to perio@fmf.nl to be featured in the next edition of the Periodiek: The final solved sudoku grid, which cells are shaded in the canal view puzzle, what move white needs to make to checkmate black.