Supporting the Life Sciences with Statistics

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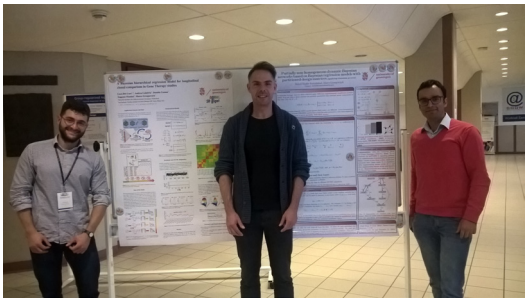
Existing statistical tools are often not capable of extracting all the valuable information from the data from collaborators of the life sciences.
There is a need for "tailor-made" statistical models to extract all the valuable data.
This knowledge can be of importance to the development of new medical drugs and treatments.



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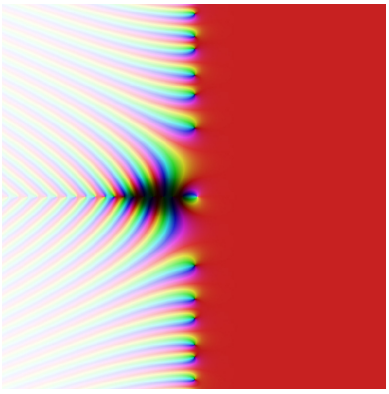
Find out what this mysterious Riemann hypothesis is and what it implies for mathematics.



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Editors
Robert van der Meer,
Jonah Stalknecht,
Gerrit van Tilburg,
Jasper Somsen,
Robert Mol

Authors
M. Grzegorczyk
M.S. Kamalbad
M. Kluitenberg
M. Deinum
L. Del Core
S. Balafas
V. Bernal
J. Jager
R. Mol

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From the Editor in Chief

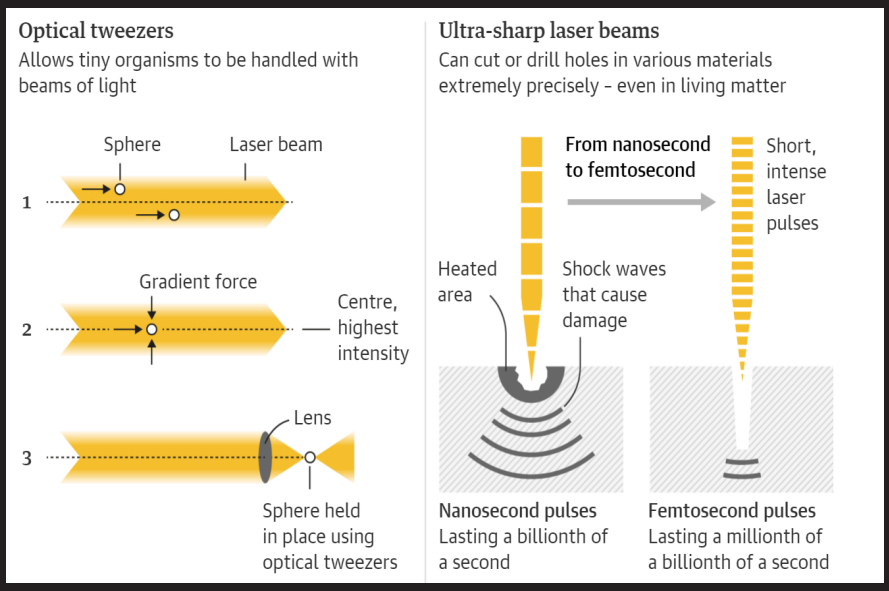
With the first issue of the new year we also bring to you a new board of editors. We are sad to have to say goodbye to Rick Vinke and Josselin Kooi, but also excited to welcome Robert Mol and Robert van der Meer to the board of editors.

This year we are going to add a new regular section to the Periodiek. Every edition we are going to have an interview with one of the professors at this university. This edition it is Gerco Onderwater.
This issue's Brainwork is a tough one, we have a lot of respect for the people who are able to solve it. We will raffle a Pyraminx (a tetrahedron shaped Rubik's cube) amongst the people that send in the correct solution.

I hope you will enjoy this slightly lighter than normal issue of Periodiek.

Jonah Stalknecht

In the News: Nobel Prizes



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ARTHUR ASHKIN


GÉRARD MOUROU


DONNA STRICKLAND

Physics

This year's Nobel Prize in physics was awarded in half to Arthur Ashkin, the other half of the prize was awarded to Gérard Mourou and Donna Strickland.

American physicist Arthur Askins is with 96 years the oldest person to win a Nobel prize. His invention of 'optical tweezers' rests on the principle of conservation of angular momentum. As light moves through a small transparent sphere, the light will be refracted. The light that has passed through the sphere will move in a different direction than the light that went in, and since light carries momentum the resulting beams will have a net momentum change. This change has to be compensated by the movement of the sphere, which will experience a force in the opposite direction as the momentum change of the light. In general this will be towards the centre of the lightbeam.

Since there is some absorption of light by the sphere, there will also be a slight force in the forward direction. To make sure the ball stays in place, Ashkin put a strong lens in front of the sphere, which focuses the light. The sphere will be drawn towards the point of highest intensity, this will exactly cancel the forward force due to absorption. Everything together creates a light trap: the 'optical tweezer'.

Donna Strickland is the first woman to win the Nobel Prize in physics in 55 years. She shares her half of the prize with Gerard Mourou. They developed a way to increase the intensity of laser beams far further than was previously possible. Since the eighties short pulses could not realistically be enhanced without seriously damaging the amplifying material. Strickland and Mourou's solution to this was quite simple and elegant. First they stretch out the light wave to decrease the peak power, then amplify it and finally compressing it in time again. This process significantly increases the intensity.

These new ultrashort, ultra-intense laser pulses have uses in a lot of different areas. They are extremely precise and can cut holes in numerous materials, even living tissue, without much heat transfer and with far fewer damaging shockwaves than before.

THE NOBEL PRIZE

Chemisty

The Nobel Prize in chemistry this year was awarded in half to Frances H. Arnold "for the directed evolution of enzymes", and the other half to George P. Smith and Sir Gregory P. Winter "for the phage display of peptides and antibodies".

Enzymes are complex biological molecules that perform highly specific tasks. For years scientists have tried to synthesise enzymes that do the things we want them to do, but due to the enzymes' sheer complexity this has proven a difficult task. Instead of directly synthesising them, Arnold modified the genes that make the enzymes. By giving slightly different mutations to a vast amount of cells, she got a lot of slightly different enzymes. Next she selected the cells that produced the most preferable enzymes, and started to induce more mutations in those. Repeating this process will lead to better and better enzymes every generation of cells.
In this (r)evolutionary way of making new enzymes using directed selection, Arnold was in a specific case able to make a variant of subtilisin that worked 256 times better than the original enzyme. Currently Arnold is using her technique to make enzymes that convert sugar to alcohols, with the idea that it can be used as a sustainable biofuel.

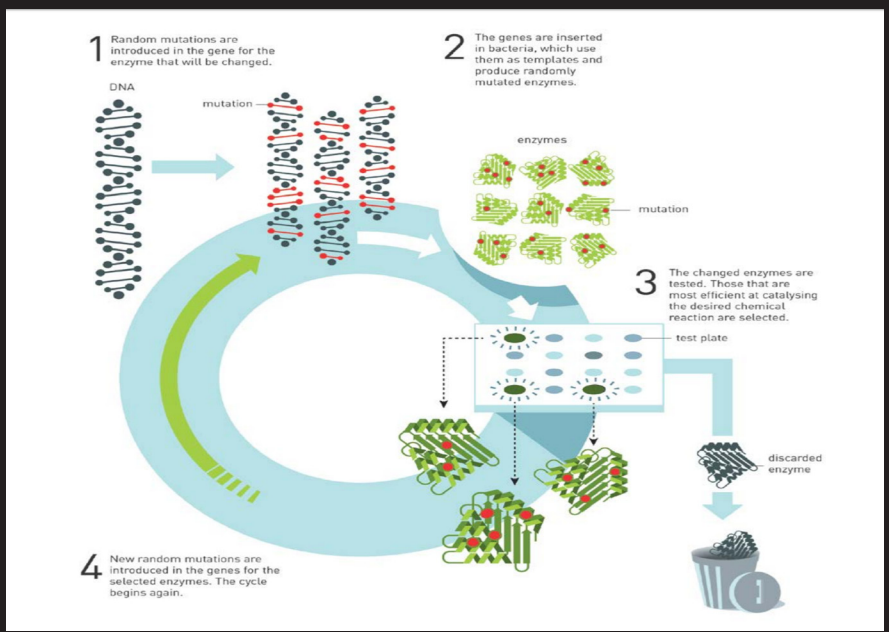
Smith and Winter also utilised evolution to their advantage. In the first half of the 1980s, Smith was trying to use viruses that infect bacteria –called bacteriophages– to duplicate genes. Smith made the phages carry genetic information of specific proteins. Antibodies bind to very specific targets, Smith used these to pick out the proteins he was interested in.
If the researchers found an antibody attached to a know protein, they would also find the previously unknown gene belonging to the protein.
The next big breakthrough using this process (called 'phage display') was however not related to gene duplication. Winter turned the idea of Smith around: he put the genes for antibodies in the phages, and used specific small molecules to fish out antibodies that had the properties he wanted. This led to a new way to produce highly efficient antibodies very quickly. New drugs based on these antibodies are more effective and have fewer unwanted side effects.
Currently, this method of antibody creation has been the basis for the production of eleven of the fifteen most sold drugs worldwide.

THE NOBEL PRIZE

FRANCES H. ARNOLD

GEORGE P. SMITH

SIR GREGORY P. WINTER



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From the Board

The life of a board member of the FMF

AUTHOR: **MARTIJN DEINUM**

FIGURE 1: The current board of the FMF

Hello! For those of you who do not know me: I am Martijn Deinum, a 23 year old chemistry student and this year I got lucky enough to be on the board of our beloved association, the FMF (If you ever wonder how a Chemistry student ended up at the FMF, don't hesitate to ask! :)).

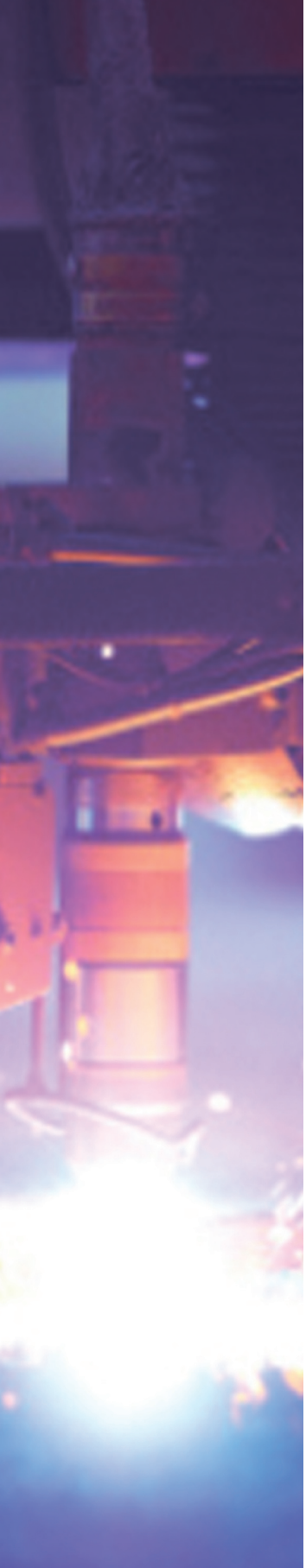
The first block of the year is over, this means that you have hopefully passed all of your exams and are 'fresh and fruity', as we say in The Netherlands, for the second half of the semester. As the board of your study association we strive to make your life as easy and fun as possible during your studies. I hope you enjoyed all the activities the committees and the board have organised during the first block.

As a new board member of the association your life gets thrown into some kind of hurricane that does not stop until approximately the first exam week. Your working times are irregular and more often than not you barely sleep. Even though it is really intense, it is also very rewarding, fun and it gives you a lot of opportunities to learn.

I would like to share some vivid memories of the first block as a new board. For example, cycling to a bar in the city center with two inflatable beds taped together all the while being suited up is probably an experience you only get once in your life. Or having a board meeting the middle of the night because you thought that was a good and fun idea (turns out, it was not).
The time has also come now to execute some plans that the 60th board has, because after a few hectic first months, we have finally settled a bit in our respective functions. One of these ideas is the idea-box, a box in which you can put handwritten ideas and initiatives that you might have. We made more money available for spontaneous initiatives, so do not hesitate to also put in the more enthusiastic ideas. This box is currently already in the FMF room! Another thing we want to change is the website. We will be looking into different options and hope to have a new, functional website and a dedicated place to put the pictures of activities by the end of the year.

If you got this far, thank you for reading! If you have any awesome ludicrous ideas, make sure to drop them in the idea-box in the FMF room! I am looking forward to the rest of the year and hope to see you in the FMF room or at one of our activities!

With Love,
~MD



Creatieve software engineer?

Hou jij van afwisseling?

Zou je je willen specialiseren in Big data toepassingen?

Geïnteresseerd in de industrie, verkeer of zorg sector?

Ben je goed in programmeren liefst in c++?

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KxA datasolutions is een innovatief bedrijf voortgekomen uit de astronomie, gespecialiseerd in data toepassingen en gevestigd op de grens van Groningen en Friesland. We werken aan veel verschillende dataprojecten. De ene keer houden we ons bezig met slimme datatoepassingen voor het verkeer de andere keer zijn we bezig met de optimalisatie van een fabriek of helpen we mee aan de ontwikkeling van een innovatieve windmolen of analyseren we onverwachte uitval in een fabriek.

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Geen auto? Wij kunnen zorgen voor vervoer.

Geintereseerd? Bel of mail!

Wilma Mulder
mulder@kxa.nl
tel. 06 15347819

{kxa}
DataSolutions

Supporting the Life Sciences with Statistics

AUTHORS: **MARCO GRZEGORCZYK, MAHDI SHAFIEE KAMALABAD, VICTOR BERNAL, SPYROS BALAFAS** AND **LUCA DEL CORE**

We are a group of statisticians at the Bernoulli Institute of Groningen University, and we work in close collaboration with biologists and medical scientists. We develop novel statistical models, with which our collaborators can analyze their experimental data. Our methodological contributions are required, as lots of information is contained in the data but cannot be extracted with statistical 'off-the-shelf' methods. There is need for 'tailor-made' statistical models that take the specific features of the data into account. We develop those models and with our network analyses we assist our collaborators to recognise important patterns and so to gain more insight. As our collaborators stem from the Life Sciences, in the long run, this knowledge will be useful for developing new medical drugs and treatments. In this paper we outline four of our collaborative projects.

Collaboration with University Medical Center Groningen (UMCG)

We are collaborating with Prof. Dr. Kathrin Thedieck and her research group from UMCG. In the research focus of Prof. Dr. Kathrin Thedieck is the so-called 'mammalian target of rapamycin complex 1' pathway (in short: the mTORC1 pathway). It is known that this is an important cellular pathway that plays a central role in ageing processes as well as in cancer development. It is therefore important to understand how this pathway is structured, and how it changes in diseased cells. The proteins of the mTORC1 pathway permanently interact with each other and form a complex regulatory network. The network enables the living cell to quickly adapt to different cellular conditions. For example, the presence of insulin has effects on the network interactions: after insulin supplementation some protein interactions get stronger, while other protein interactions get suppressed. The research objective is to learn the whole topology (structure) of the mTORC1 pathway and to understand how it changes in response to different cellular conditions. This does not only give important insights into how life is organised at the molecular level. This knowledge is also of essential importance for identifying promising new drug targets as well as for developing personalised medical treatments.

As cellular interaction networks cannot be observed, the only possibility to gain knowledge about the regulatory mechanisms is by performing experiments and collecting data. In laboratory experiments the concentrations of the phosphorylated (i.e. active) protein concentrations can be measured over time, e.g. via immunoblotting. After the experiment, the objective is to learn the network structure (i.e. all regulatory interactions) from the measured protein concentration data. And that is, where 'we' —the statisticians— come in…

Network structure learning is a very challenging task, as the number of possible network structures grows superexponentially in the number of proteins. From a statistical perspective we are used to ask: 'For which network structure would the observed data be most likely?' (Maximum Likelihood) or 'Which of the possible network structures is most likely to have generated the observed data?' (Posterior Probability). But the answers to these questions strongly depend on how the network interactions are statistically modelled. So we first have to address questions such as: 'What kind of molecular interactions are there between the concentrations?', 'Can the relationships be modelled via basic linear regression?', and 'Are there special biochemical reaction kinetics, so that more flexible models are required?'.

To find the best trade-off between a faithful biological description and a statistically feasible model, there is need for a close collaboration between biologists and theoreticians.

Collaboration with the Groningen Research Institute of Pharmacy (GRIP)

The PhD position of Victor is funded by the Data Science and Systems Complexity Center (DSSC) of our Faculty of Science and Engineering (FSE). Victor is co-supervised by researchers from GRIP, namely by Prof. Dr. Peter Horvatovich, Prof. Dr. Rainer Bischoff

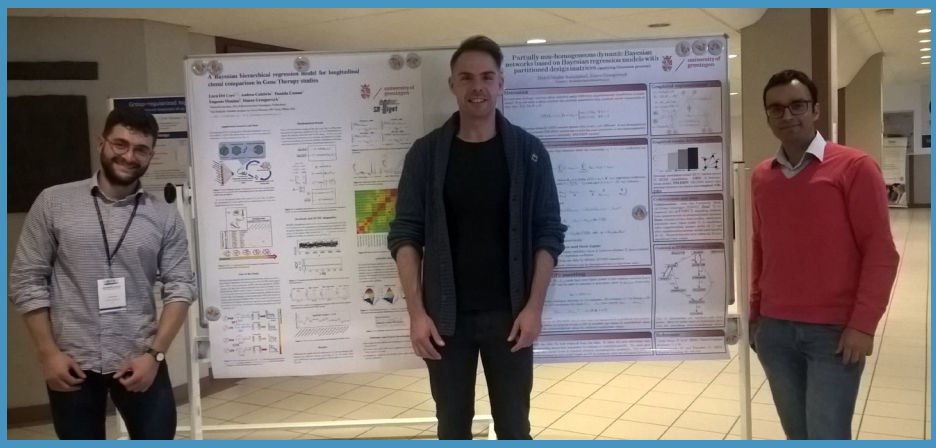


FIGURE 1: Research posters that we exhibited at the conference of the European Cooperation for Statistics of Network Data Science (26-28 September 2018 in Warsaw, Poland). From left to right: Luca, Marco and Mahdi

and Prof. Dr. Victor Guryev. The goal of Victor's PhD project is to develop and to implement novel network methods for analysing clinical data.

Our long-term goal is to develop a complete statistical analysis pipeline for automatised network reconstruction from molecular data. Via GRIP we are involved in many different subprojects, but for lack of space we only give here one concrete example:
Chronic obstructive pulmonary disease (COPD) is a widely spread and severe lung disease. The lungs of COPD patients lose their ability to repair damages, as the disease progresses. COPD reaches different stages with increasing clinical symptoms that worsen the life quality of the patients more and more. Unfortunately, there is no cure for COPD; only the symptoms can be eased by medical treatments.

From molecular biology it is already known that the activities (i.e. expressions) of certain genes, and thus the cellular gene regulatory networks, alter with the COPD stage. For developing treatments to cure COPD, it is thus of great importance to understand how COPD affects the cellular gene regulatory networks: 'What exactly happens within the lung cells, as COPD progresses?'. To diagnose and to study the effects of COPD, tissue samples from the lung (bronchial epithelium) can be taken and analysed. But taking tissue from the lung is obviously an invasive intervention, and thus very inconvenient for patients. Therefore it is intensively searched for less invasive alternatives. In a recent research project, our network analyses have shown that the gene expressions in nasal and bronchial epithelium of COPD patients have interesting co-patterns. That is, our statistical results suggest that COPD can perhaps be diagnosed and staged based on nasal instead of bronchial tissue. This would be very beneficial, as extracting nasal epithelium is less invasive and hence less inconvenient for patients.

Collaboration with the San Raffaele Telethon Institute for Gene Therapy (SR-TIGET) in Milan

SR-TIGET funds the PhD position of Luca to strengthen our collaboration on developing new methods for the statistical analysis of gene therapy data. Luca's co-supervisors from SR-TIGET are Dr. Eugenio Montini and Dr. Andrea Calabria.
In recent years, stem cell gene therapy has become a very important medical treatment for children suffering from genetic disorders. Genetic disorders are often inherited and not rarely caused by unfortunate parent constellations. The treated children are very young and have one or more faulty or missing genes. Often the children could not even survive without a gene therapy treatment.

The idea of a gene therapy is to introduce healthy genes to the patient and to alleviate the problems caused by the faulty genes. Viruses, such as the HIV virus, are used as carriers to insert the healthy genes. But first the virus has to be genetically modified, such that it cannot cause diseases anymore. Then the virus is genetically engineered to deliver the healthy genes to the patients. Finally, the patient's stem cells are infected with the synthetically redesigned virus. After infection, the virus spreads and infects more and more stem cells by integrating healthy gene copies into the regular stem cell genome. As the stem cells differentiate into other cell types, the healthy genes spread over all body cells what finally can lead to a cure. Usually the virus-transmitted healthy genes are tagged so that they can be distinguished from the

regular genes. After a gene therapy treatment it can then be monitored over many years how the tagged healthy genes (integrated via the virus) distribute over the different cell types. It is a good indication of a successful gene therapy treatment when the integrated genes distribute well (i.e. as uniformly as possible) over all body cells.
Questions that we will address within Luca's PhD project are: 'How can we best quantify how uniformly the integrated genes distribute among the patient cells?', 'Are there relationships between the different cell types or other underlying patterns that have not been discovered yet?', 'Can we give an early prediction whether the gene therapy treatment has been successful?', and 'Does the success rate depend on the virus type?'. By answering these questions, we hope that we can contribute to the development of safer gene therapy treatments.

Collaboration with the Interdisciplinary Center Psychopathology and Emotion regulation (ICPE)

Spyros is co-supervised by Prof. Dr. Ernst Wit from Lugano University, and unlike our earlier described research projects, Spyros's project is not on learning networks from molecular data, but on learning symptom-symptom networks from psychometric data. Spyros has an interdisciplinary collaboration with Prof. Dr. Hanneke Wardenaar-Wigman from ICPE. The goal of this collaboration is to develop novel statistical methods for learning symptom-symptom networks of mental diseases.

According to the so-called 'network theory of mental illnesses', psychiatric disorders can be described in form of networks of interacting symptoms. That is, each mental illness can uniquely be specified by a network of symptom-symptom interactions. Spyros PhD project is on developing novel statistical models for learning those symptom-symptom interactions from longitudinal data. From a statistical perspective, there are two main challenges: First, symptoms can often only be described on a discrete scale; e.g. discrete levels ranging from 'mild' to 'severe'. And second, there are contemporaneous as well as dynamic interactions in the symptom-symptom networks. That is, if symptom A has an effect on symptom B, the values of A and B might be correlated (contemporaneous interaction) or symptom A might cause symptom B with a time delay (dynamic interaction). In the latter case, the values of A and B are not necessarily correlated when measured at the same time point.

As there is no standard statistical model for this type of data, Spyros is developing novel statistical models that can take these unusual features into account. Gaining insights into the complex mechanisms of psychiatric disorders is of great importance, not only for better understanding the generative mechanisms of mental illnesses, but also for finding better patient treatments. For example, the symptom-symptom networks can be used to better distinguish between different mental diseases as well as to distinguish between the different stages of one particular disease. In the long run, the research of Spyros has therefore the potential to lead to more accurate psychiatric diagnoses, and thus to more suitable psychomedical treatments for the patients.

Closing remarks

In this article we have outlined four ongoing research projects, in which our group is involved. In particular, we have tried to highlight how we support the Life Sciences with our statistical contributions.
If you are a researcher with data, from which you would like a network to be learnt, please do not hesitate and get in touch with us.
If you are a Mathematics student with interest in our methodological research, please consider contacting us for a Bachelor or Master project.

Acknowledgements

Marco thanks Prof. Dr. Ernst Wit for the support, guidance and inspiration during the last five years•

References

Bernoulli Institute (BI) for Mathematics, Computer Science and Artificial Intelligence
Rijksuniversiteit Groningen (RUG)

Contact: m.a.grzegorczyk@rug.nl
Weblink:
http://www.math.rug.nl/stat/People/Marco

The Riemann Hypothesis

AUTHOR: **M. KLUITENBERG**

Recently, mathematician Sir Michael Atiyah announced that he had found a proof for the long standing 'Riemann hypothesis'. Most mathematicians seem to agree that his proof is not correct; it seems to rest on the 'Todd function', which is nowhere clearly defined. In any case, this certainly won't be the last attempted proof of the mysterious Riemann hypothesis. In this article, I will try to explain what the Riemann hypothesis means, and what it implies for mathematics.

The starting point for defining the Riemann zeta function, is to consider the infinite series

$$f(s) = \sum_{n=1}^{\infty} \frac{1}{n^s},$$

where s is some real number. To get an idea of what this function does, let's fill in some special values of s. When $s = 2$, we get $f(2) = \sum_{n=1}^{\infty} \frac{1}{n^2}$. Finding the value of this series in known as the 'Basel problem'. In 1735, Euler calculated that the exact value of the series is, surprisingly, $\frac{\pi^2}{6}$. At the time, some of the manipulations with infinite series that Euler uses were not properly justified, but many different rigorous proofs were given later. One simple way to solve the Basel problem is by using the Fourier series of $g(x) = x^2$, which is done in the course 'Mathematical Physics'.

"Some people may try to convince you that this series equals -1/12, but don't be fooled!"

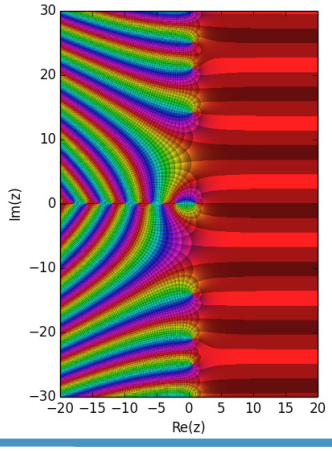


FIGURE 1: A cool visualisation of the Riemann zeta function

The value $s = 1$ gives the famous 'harmonic series', which is known to diverge. Hence, the function f is not defined for $s = 1$. In fact, it is not so difficult to show that the series diverges for any $s \leq 1$, and converges for any $s > 1$. That the series diverges for $s \leq 1$ is quite clear in the case $s = -1$. In this case:

$$f(-1) = \sum_{n=1}^{\infty} n = 1 + 2 + 3 + \dots$$

Some people may try to convince you that this series equals $-\frac{1}{12}$, but don't be fooled! It is a divergent series, so we cannot assign a value to it.

There is no problem extending f to the complex plane. As long as $\mathrm{Re}(s) > 1$, we get a well-defined, complex-valued function. We're not done yet. The Riemann zeta function is defined by extending f to the whole complex plane (except $s = 1$) in a 'natural' way. Here, the word natural means that ζ is an *analytic continuation* of f.

Analytic functions are the complex equivalent of differentiable functions on the real line. A function $f : \mathbb{C} \to \mathbb{C}$ is called analytic (on an open set $U \subset \mathbb{C}$) if for all $s \in U$ the limit

$$\lim_{z \to s} \frac{f(z) - f(s)}{z - s}$$

exists. Somewhat surprisingly, the notion of analyticity is much stronger than that of differentiability on $\mathbb{R}$, even though the definition is the same. For example,

if a function is analytic on U, then all derivatives of f exist, and are continuous. On the real line, it's easy to find counterexamples to this. For example, the function:

$$f(x) = \int_0^x |t| \, \mathrm{d}t$$

is once, but not twice differentiable. Similarly, one can find a function which is n times, but not $n+1$ times differentiable.

"You will win the one million dollars."

Another nice property of analytic functions is that the coordinate curves ($x \mapsto f(x+iy_0)$ and $y \mapsto f(x_0+iy)$) through each point are orthogonal. If you took a course on complex analysis: this follows from the Cauchy-Riemann equations. This innocent looking property has some very strong consequences: the behaviour of an analytic function is completely specified by its behaviour on some small open neighbourhood U. *Just keep the coordinate curves orthogonal!* This leads to the following definition:

Definition. *Suppose that f is an analytic function defined on a non-empty open set $V \subset \mathbb{C}$. A function $F : U \supset V \to \mathbb{C}$ is called an analytic continuation of f, if $F(s) = f(s)$ on the smaller set V, and is F is itself analytic.*

Analytic continuation is unique in the following sense: If U is the open and connected domain of two analytic functions $F_1, F_2 : U \supset V \to \mathbb{C}$, and $F_1(s) = F_2(s) = f(s)$ for all $s \in V$, then $F_1 = F_2$ on U. In this way, we define the Riemann zeta function as the *unique* analytic continuation of $f(s) = \sum_{n=1}^{\infty} \frac{1}{n^s}$, to the domain $U = \mathbb{C} \setminus \{0\}$.

Interestingly, $\zeta(-1) = -\frac{1}{12}$, so somehow the most natural value to assign to the divergent series $1+2+3+\cdots = -\frac{1}{12}$. In mathematics, there are several ways to assign values to divergent series. One such method is via analytic continuation. There are also the Cesàro and Abel summation conventions. However, neither of these can assign a value to $1+2+3+\ldots$. A more advanced technique, called Ramanujan summation, does assign the value $-\frac{1}{12}$ to this series.

The Riemann hypothesis is a statement about the zeros of ζ. There are the 'trivial zeros' are $s = -2, -4, \ldots$.

It is known that all nontrivial zeroes are located in the critical strip $0 < \mathrm{Re}(s) < 1$. This leads to:

Riemann Hypothesis. *All nontrivial zeros of the Riemann zeta function lie on the critical line:* $\mathrm{Re}(s) = \frac{1}{2}$.

A connection between the Riemann zeta function and prime numbers was already found by (who else) Euler:

$$\sum_{n=1}^{\infty} \frac{1}{n^s} = \prod_{p \text{ prime}} \left(\frac{1}{1-p^{-s}} \right).$$

Assuming the Riemann hypothesis, we can prove results about the distribution of prime numbers. If $\pi(x)$ denotes the number of primes less than or equal to x, then the Riemann hypothesis implies

$$\pi(x) = \mathrm{Li}(x) + \mathcal{O}(\sqrt{x}\log x), \quad \mathrm{Li}(x) := \int_2^x \log(t)\, \mathrm{d}t.$$

The Riemann hypothesis also gives a bound on gaps between adjacent prime numbers:

$$p_{k+1} - p_k = \mathcal{O}(\sqrt{p_k}\log(p_k)).$$

Of course, the Riemann hypothesis is not only useful for answering number theory questions. It's also just a very hard problem, which will probably require the invention of new mathematical techniques. Unless of course, someone finds a counterexample. It requires just one nontrivial root, which is not on the critical line. So, get searching, and maybe *you* will win the **one million dollars**•

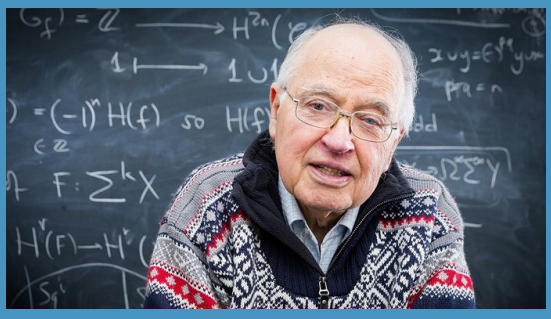


FIGURE 2: SIr Michael Atiyah, the mathematician who claimed to have found a proof for the Riemann hypothesis

Perio Interview: Gerco Onderwater

GERCO ONDERWATER

A brand new section in this magazine: Perio Interview, with Gerco Onderwater as first participant. Associate professor Onderwater is a well known person at our university, famous among students for teaching courses in the bachelor and the master of physics. We learnt what Gerco likes for breakfast and that he enjoys making photographs (like the one you can see on the cover), as well as plenty of other interesting things.

First of all, what do you consider to be your field of research?

I'm an experimental particle physicist, so I'm into experimenting, not theory. Particle physics deals with everything smaller than an atom. Within the field, I'm not really building things but I'm more of an analytical physicist. Meaning I work with data analysis, data simulation, data manipulation, extracting data from bites; bites to business.

For how long did you want to become a professor?

POAH! I sort of rolled into it really. It was not my kindergarten dream or something. My career is a long string of, I would not say accidents, let's call them happenings. I started with applied physics because, why not? When visiting universities, I thought, economics is nice but they don't have things. Philosophy is bad for jobs and in the end I chose to do applied physics in Enschede. After this I first started to do low temperature physics, superconductivity. Unfortunately, my proposed graduation professor died, leaving one professor with 40 students, which was too much. So I switched to laser physics and worked for my research project at TNO, outside of the university. Then I graduated and the Dutch military threatened to incorporate me at the military service. So I quickly had to find a PhD project which turned out to be in nuclear physics, which I knew nothing about. They hired me anyway so then I worked there for four years. Then I found a postdoc position in the US. This all

"I found a postdoc position in the US because I had a bet with a collegue about putting the word 'potato' inside his PhD thesis."

played out because of a bet I had with a colleague about putting the word 'potato' inside his PhD thesis. This is a very risky thing to do. One typo in a thesis is okay, but two typos makes you a loser, let alone a weird word. He had a position in the US and because he won the bet, I had to drop by to deliver a bottle of red wine. Being Dutch, I wanted to do it cheap, but I could not stay at his place. So we had to find a way to make the university pay for it, so I did a seminar there. Then I asked the university whether they wanted to hire me for a postdoc and in the end they offered me a job. I worked there for 5 years. After that the immigration service wanted to kick me out. I found grants in the Netherlands and that is how I ended up here.

Did you have any dream jobs as a kid?

Not that I remember, I was always messing around in the garage, building crossbows and making fires.

Are you able to fix your own bike?

If I want to, yes. But honestly I'm too lazy for that so I prefer not to. You should let people earn a decent living as a bike repairer.

What research do you spend most time on at this moment?

Something called lepton universality. In particle physics there's all sorts of particles, the electron is the most famous lepton and there are two other. According to theory, these three are exactly the same except for their masses. What we are doing in our group is checking whether or not the particles are behaving the same under extreme conditions. As of yet, the answer is yes. But there are hints that there might be something wrong. In particle physics, everything has an uncertainty based on counting statistics and we have a deviation from what is expected by 3 standard deviations. This means that it is not consistent but also that it is something that could go every way. This research is happening at the LHCb experiment at CERN.

"Newspapers from all over the US were there and we even made it to the cover of Time magazine and the New York times"

Which professional accomplishment are you most proud of?

In the end of my American career, as assistant professor, I worked in a group of about 70 scientists studying the muon g-2. At some point there I was the analysis coordinator of that experiment, which was about 30 people working on one analysis for about a year and a half. So I was to steer that and the result of this analysis stirred up some noise in the community because it was deviating from the the standard model. Since I was the analysis coordinator I had to present the result at an actual press conference at the lab. Newspapers from all over the US were there and we even made it to the cover page of Time Magazine and the New York Times. Whether it was an accomplishment I will not comment on, but it was definitely a moment in the spotlights.

FIGURE 2: A photo made by Gerco

Which personal accomplishment are you most proud of?

Once upon a time I used to be a fairly decent volleyball player. That ended when I decided to pick up a university education. I was playing national volleyball and we were national Dutch youth champion two years in a row. That was long ago, but recently there has not been much personal accomplishment except for having two nice kids and so on.

What is your favourite equation?

A large part of what makes my life easier is the Taylor expansion and the Fourier transform. It is amazingly powerful, that's the cool thing. They sometimes give it a more fancy name like 'effective field theory' where you make a truncated series of Feynman diagrams, but in the end it is the same trick as a Taylor expansion.

What is/was your least favourite physics subject?

There is a big difference between "then" and "now". What I struggled with was computational physics. I filled a full pallet of grades before I finally passed it. But nowadays my everyday life is computational physics front to back and three times around. Now, I have no clue in the world how it was possible to have failed that even once. I won't call it my least favourite subject but it did just not resonate with me.

FIGURE 3: Another photo made by Gerco

Now, anything that has the subject bureaucracy next to it is just almost always a waste of time, in my view. It has nothing to do with research and teaching. It serves a goal, but it should not be overdone.

What are your hobbies?

I still play volleyball, at a less ambitious level. I did not play for twenty years but a neighbour convinced me to start again. Then you have the brain of a twenty year old and the body of a 40 year old which is a combination that lasts for about 3 months. Then something rips off and you find yourself in the hospital. That made me realise that the level of ambition should be tempered and now I'm playing in the team that is designated "putje van de club", meaning that is where everyone over 25 or so is playing. Apart from that I have ambitions of being a photographer. Actually my whole family has it as a hobby so we sometimes adjust our vacations to that as well. That's actually also a hobby: to go far and long.

What did you have for breakfast?

Two slices of bread with chocolate paste and a cup of milk. Coffee first thing in the morning is a little too much, but I generously make up at work.

What kind of music do you like?

I think I have zero music abilities. Music-wise, I like eclectic music, meaning whatever suits the moment. That's classic, or something calming after lectures like Coldplay or Armin van Buuren. After a frustrating meeting something aggressive is better.

If you had to choose between giving every lecture at 19:00 or having someone eating fish in the front row in every lecture, which would you choose?

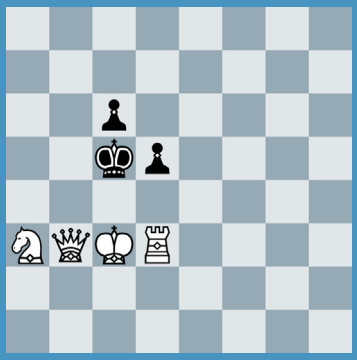
I would go for the fish then because if it is not too fishy I also like it myself. Teaching from seven to nine in the evening would not be nice for my family, because a family dinner is what we try to accomodate.

Pick one again: doing research in a field that you find very interesting or winning a nobel prize for something uninteresting?

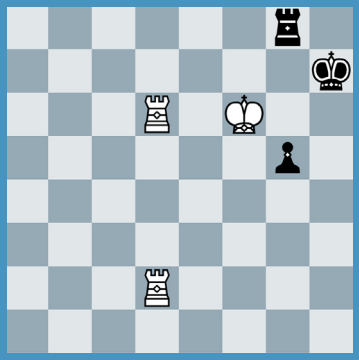
I much rather enjoy myself, that's worth more than winning a nobel prize. It is nice but it starts to attract all sorts of unwanted complications. Nobel prize winners typically come in two kinds. One are the assholes that think they deserved the prize long ago and that is a shame that it took so long. The other kind recognises that it is a big burden because all of a sudden everyone wants stuff from you•

Solutions Previous Brainwork: Algebraic Chess

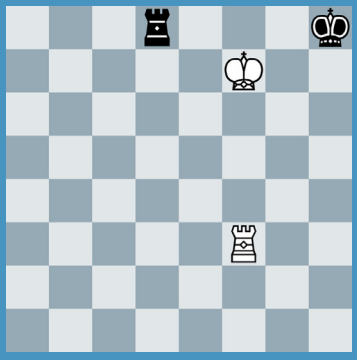
Using Kronecker multiplication, logic and some basic knowledge of chess you were able to find 4 chessboards (including pieces). All boards had a checkmate in one on them. The correct boards and checkmates can be seen below.



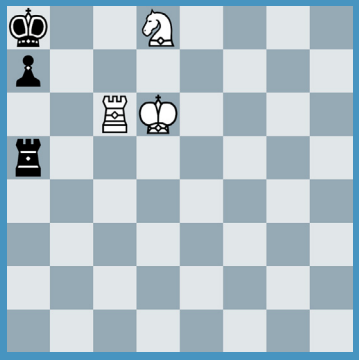
BOARD 1: Qb4#



BOARD 2: Rh2#



BOARD 3: Rh3#



BOARD 4: Rc8#

Congratulations to the following people for sending in the correct solution to the previous brainwork puzzle (in no particular oder):

Harmjan de Vries, Robert Modderman, Jari Hoekstra, Bas Wijnen, Martijn Kluitenberg, Dijs de Neeling, Martijn Deinum (close enough).

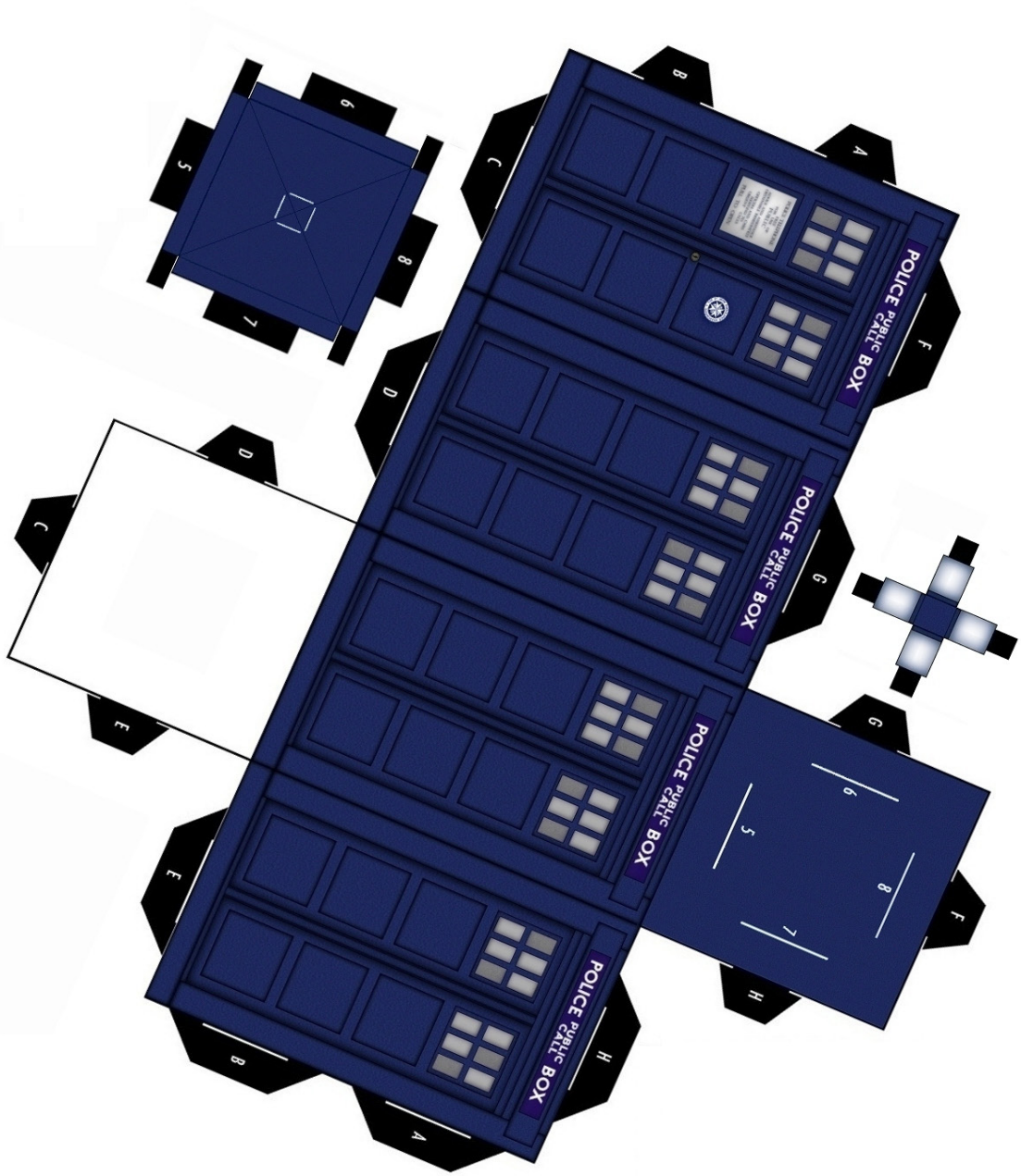
You can come collect their (small) prize at the FMF room! Please ask an FMF board member or someone from the board of editors•

MAGNUS CARLSEN

AUTHOR: **NAOMI RASPE**

Just like the tardis, the Craftcie has more content in store than one can tell. Come to our forthcoming "Build a Snowman" activity on December 20th or a projectile weapon craft activity somewhere around January!

Have fun,
the Craftcie



AUTHORS: **JOHAN JAGER** AND **ROBERT MOL**

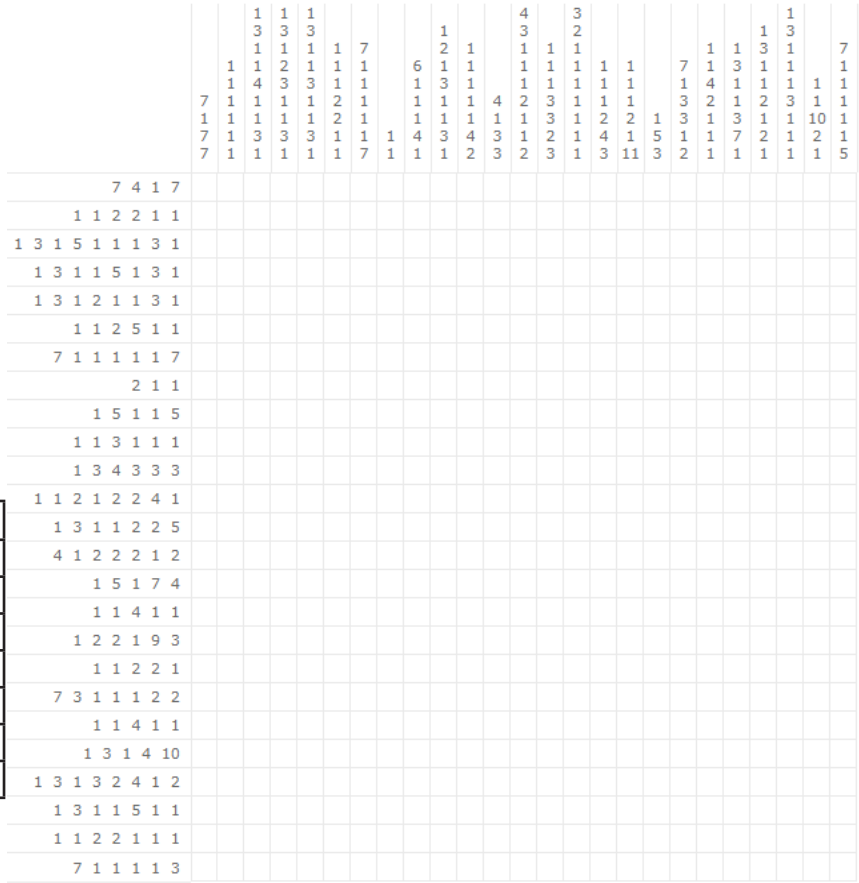
Brainwork: Save the Day

Due to stressful exams the creators of this edition's Brainwork have completely forgotten what day it is and are now completely clueless. They however do have a nonogram that was mistaken for a calandar and a useful list of translations of each day of the week. Can you help them?

This weeks Brainwork is a tough one. As an incentive to complete it we will raffle a Pyraminx amongst the people that send in a corrct solution.

What day is it?
Welke dag is het?

Dutch	English
Maandag	Monday
Dinsdag	Tuesday
Woensdag	Wednesday
Donderdag	Thursday
Vrijdag	Friday
Zaterdag	Saturday
Zondag	Sunday



AUTHOR: **ROBERT MOL**

Pofkes

Winter is approaching fast, time to make oliebollen. Or pankcakes. Or maybe poffertjes. If the choice is too much to bear, just like the crushing realisation that you are missing out on Terschellinger culture then here is just the thing, Pofkes.

Ingredients

500 grams of self-raising flour
2 eggs
175 grams of sugar
250 grams of cranberries (or raisins)
250 ml of milk
Sunflower oil
A pinch of salt (optionally)

Kitchenware

Kitchen stove
Batter bowl
Bowl
Baking pan
Spatula / Fish slice
Tablespoon
Mixer or whisk

FIGURE 1: Pofkes

Recipe

Boil water. Let the cranberries/raisins sit in a bowl of hot water for at least 5 minutes.

Mix the flour, milk, sugar, eggs, salt, in the batter bowl until it becomes a smooth batter. Take the cranberries/raisins out of the water and add them to the batter, stir again so they are approximately evenly spread out. The batter thickness should be such that it slowly drips off a spoon.

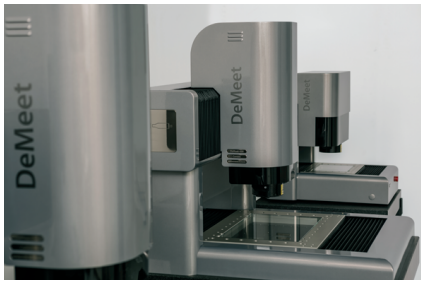
Heat the baking pan on a stove with a layer of sunflower oil covering the bottom.

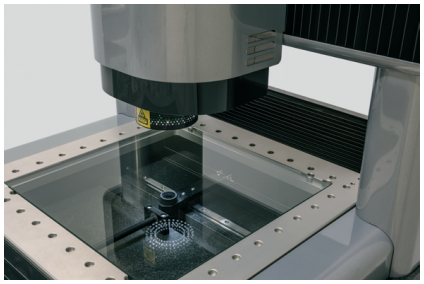
Use a tablespoon to put balls of batter into the baking pan, depending on the size of the baking pan about 4 or 5 pofkes should fit at one time. They should not spread out throughout the whole pan like a pancake would. Let the pofkes slowly turn gold-brown and flip them over for the other side to reach the same colour.

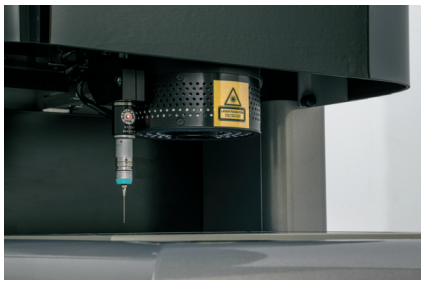
Repeat until you run out of batter. Occasionally add oil.

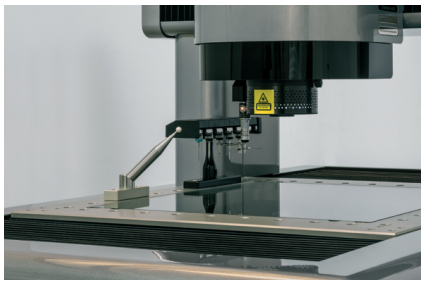
Serve the pofkes with powedered sugar (or without, whichever you prefer). They are best eaten warm but can just as well be eaten the next day as leftovers if you put them in the fridge.

Pofkes can vary in size and, mostly, in shape. You can opt to use more/less/no sugar to change the sweetness•









Schut Geometrische Meettechniek is een internationale organisatie met vijf vestigingen in Europa en de hoofdvestiging in Groningen. Het bedrijf is ISO 9001 gecertificeerd en gespecialiseerd in de ontwikkeling, productie, verkoop en service van precisie meetinstrumenten en -systemen.

Aangezien we onze activiteiten uitbreiden, zijn we continu op zoek naar enthousiaste medewerkers om ons team te versterken. Als jij wilt werken in een bedrijf dat mensen met ideeën en initiatief waardeert, dan is Schut Geometrische Meettechniek de plaats. De bedrijfsstructuur is overzichtelijk en de sfeer is informeel met een “no nonsense” karakter.

Op onze afdelingen voor de technische verkoop, software support en ontwikkeling van onze 3D meetmachines werken mensen met een academische achtergrond. Hierbij gaat het om functies zoals ***Sales Engineer***, ***Software Support Engineer***, ***Software Developer (C++)***, ***Electronics Developer*** en ***Mechanical Engineer***.

Je bent bij ons van harte welkom voor een oriënterend gesprek of een open sollicitatiegesprek of overleg over de mogelijkheden van een **stage-** of **afstudeerproject**. Wij raken graag in contact met gemotiveerde en talentvolle studenten.

Voor meer informatie kijk op **www.Schut.com** en **Vacatures.Schut.com**, of stuur een e-mail naar **Sollicitatie@Schut.com**.

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