Francken Abroad
Living in Edinburgh, Scotland

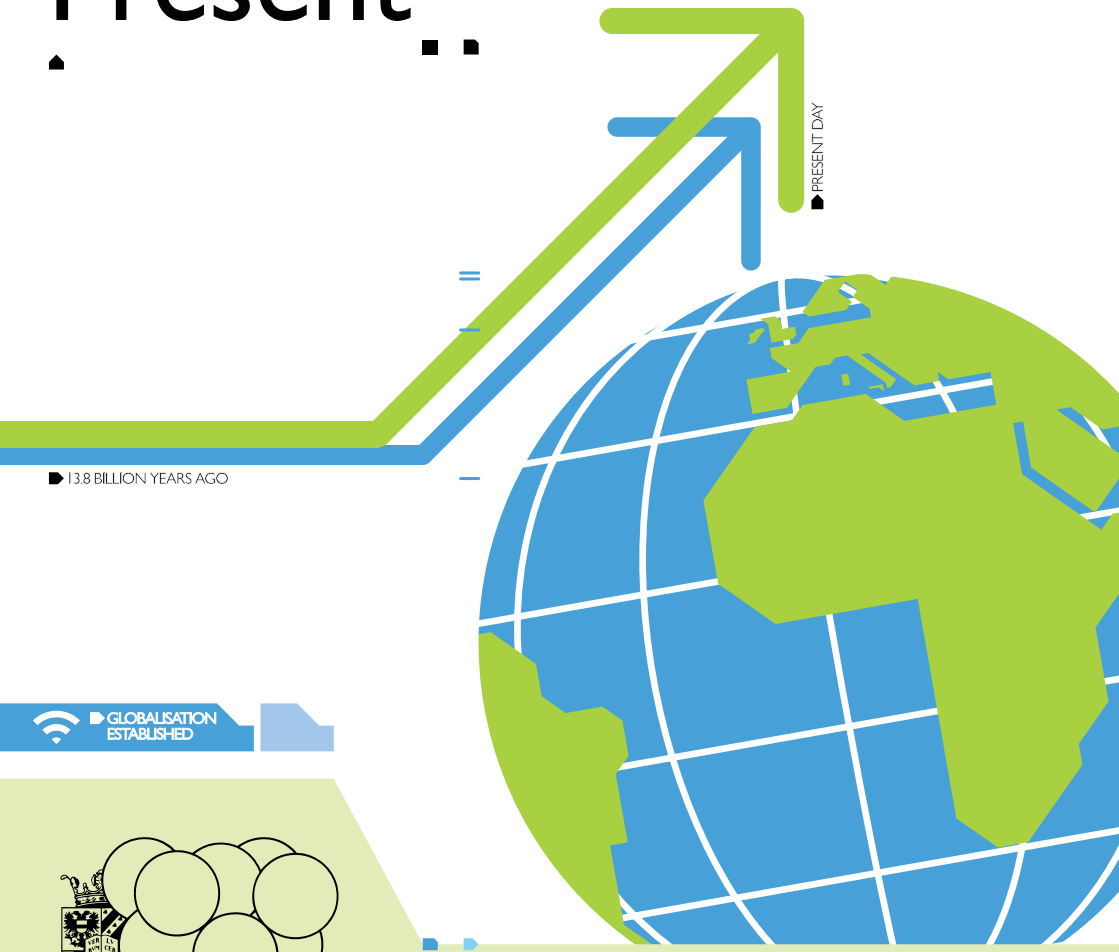
Theorist
The story continues

COVID-19
Mathematics: A 'simple' description

Francken Vrij

GILL SANS MT PRO

Present..



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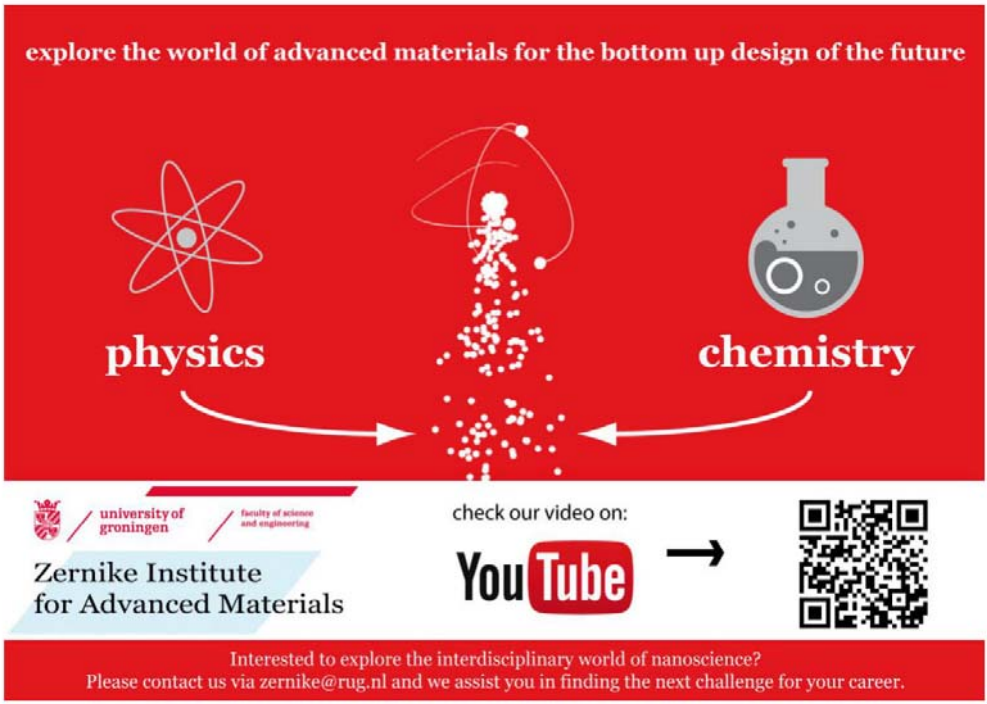

Are you interested in joining our team for a Bachelor-, Master-, or PhD-project? Check our website http://www.rug.nl/research/zernike/education/ on the different educational programs or directly approach us via zernike@rug.nl.

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Editorial

I'm glad that I can, finally again, *present* the next Francken Vrij to you! I know that we have stagnated for a bit, but if all goes according to plan we'll still send out all editions before the next acadamic year.

The theme of this edition is "*Present*", which is the next step in our plan of going through the three phases of time. When we decided we were going to do "*present*", we were actually afraid *present* wasn't going to be a very interesting topic. But we were '*in luck*' and the *present* became something a lot of interesting things could be written about. Enjoy reading!

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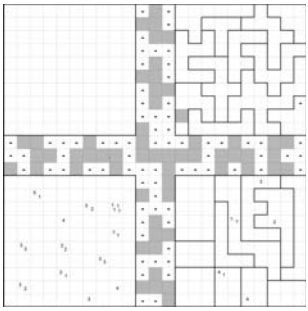
Edition 24.2

15 Puzzle

Arjen Kramer

For this edition Arjen found it important to make a puzzle to occupy you for a while. That's why he put four puzzles in one!



25 Mathematics of COVID-19

Ir. Paul Wijnbergen

If you want to make your first steps in modelling a virus outbreak then you might want to read Paul's column. Paul shows you how you can esily model the spread of a virus yourself.

20 Present

Jelle Bor MSc.

This edition Jelle will continue where he ended it in the last edition. In this article we are looking for possible solutions to the mysteries around dark matter and dark energy.

Chair's preface

By Chantal Rikse

Dear Franckenmembers,
As I am writing this, the weather outside is beautiful. I hope you're all enjoying it as much as I am. Temperatures like these make it unnecessary to travel during our vacation, which comes in handy, since it's not really an option currently. It makes staying at home a bit more enjoyable.

The pandemic has had, and still has, a great impact on all of our lives. It's been a while since we've last seen each other in real life. We can't hang out in the Francken room anymore, but it's only a small price to pay when it saves lives. I hope you're all doing well and please stay safe. Regulations are already loosening up a bit, so if everything goes well, it won't be long until we can see each other in real life again. Until then: enjoy reading this Francken Vrij!

News of the Association

By Sibren Wobben

Even though I am no longer secretary while writing this, I still get the honour of writing the news of the association for you. As the Francken Vrij was a bit late with its editions this year, I won't take you through all noteworthy events from last edition up to the present, but I'll write as if this edition was released at it's scheduled time. Since it has been such a long time let me quickly get to reminding you which amazing events we hosted:

1001 Bitterballs borrel

For the second year in a row we, had an amazing bitterballs borrel. It was funny to see that you just have to shout "*free bitterballs*" to people and all of a sudden they show up in huge numbers. During this event the Borrelcie annouced the start of the their adtvent-calender, which was all fun and well, but they wouldn't have been able to have this event if it wasn't for Fom helping in the preparation of the bitterballs.

Figure 1: Proof Fom helped out frying.

Sinterklaas-poem day

One of our least official but most important events of the year. As the Fraccie didn't prepare *schoentje zetten* this year, Bradley took it into his own hands to arrange an amazing event. On 5th December, Sinterslee, read all received poems to us and decided Gertjan left him the best poem.

VrijmiBor

This year we had the pleasure of one of our former chairs, Jelle Bor, providing us with a Francken Friday Lecture. Jelle talked about his master's research into the glueball. Luckily there were some people in the crowd that were very interested and understood what he was researching because it is still blowing my mind.

Tour the Francken

You cannot have a complete Francken year without the Borrelcie hosting the Tour the Francken. I will obviously remember this as one of the better events of the past year. The icing on the cake was that, for the first time ever, the Borrelcie-team won their own event! However, they won so spectacularly that from a competitive point of view, it was barely worth watching. The entire top four of the Tour consisted of Borrelcie members.

Christmas dinner

Our annual Christmas dinner was a great success this year! I'm always pleasantly surprised by the quality with our members' cooking. However, something I'll probably never be pleasantly surprised about is the amount of ~~awful~~/amazing sweaters our members own.

Christmas Gala

After filling our stomachs with the dinner, we dressed up, and enjoyed a lovely gala together. This year we expanded the roster of associations with whom we organise the gala! We partied with our friends from Zaza (Dutch Langu-

age and Culture), Siduri (Middle Eastern Studies), and Gerardus van der Leeuw (Theology and Religious Studies). After making *Het Heerenhuis* unsafe for a couple of hours, most of us headed into the city to spend the rest of our evening there.

Proof that members dare to wear ~~awful~~/amazing sweaters

Intermediate General Members Assembly

Since we had a lot to discuss during this GMA, we had to break it up into two pieces. The first half was held just after our exhausting lustrum week (in hindsight maybe not the smartest idea) and the second half in December. This GMA saw the complete discharge of board Statisch, who couldn't be happier with receiving the honorable positions of becoming members for an indefinte amout of time! Sadly Chantal could not be there physically, but thanks to the wonders of the internet she could still make it to the GMA:

Life before and during corona

By Tabitha Minett, Sibren Wobben, and Jeanne van Zuilen

Life before corona, by Tabitha Minett:

It's been many long, hard months since we've had the pleasure of sitting together in the Francken room, so I'd like to take you on a little trip down memory lane to remind you of the good times and look forward to when this craziness is all over.

You traipse into the Francken room just after 9 for your first caffeine boost of the day. Someone is lying across the sofas, another has their nose in a textbook, and a third is chilling at a computer. You find your mug on the door and decant some coffee into it.

After your morning lecture, you hear the faint sounds of the Vengaboys coming from the Fracken room. After you've striped a chocomel, you sit and play a few *takjes* of klaverjas.

The early afternoon belly grumble means it's time for a tosti. You wonder if it is worth using the dirty grill, but needs must. Kathinkabot kindly reminds you of the time, and annouces to the room that a member has broken wind.

The countdown on the TV catches your eye, and the sweet sound of Enya indicates it's time for a nice cold one. Soon after, the room is being prepared for a Francken Friday lecture; the topic is very interesting, but half of us can't quite get our head around it. But a bottle of Gebouw 13 and a pleasant atmosphere makes for a lovely afternoon. The wonderful talk is followed by much merriment, but the night really begins when someone suggests we head to Negende. You wake up the next day and start doing it all over again.

Covid-19 was announced a pandemic on 11th March 2020. The following day, our university announced it was halting physical classes and research on campus, and moving to online teaching. Everyone's life changed overnight and we quickly had to adapt. I thought this edition wouldn't be complete without a few members describing what life has been like during this crazy period.

Jeanne van Zuilen:
Even though the world stopped for a little, your lingering thirst for Gebouw 13 has (probably) not. The Brouwcie has brewed approximately 500 liters of beer this year, which normally is brought to the Francken room so that we can enjoy it all together. The room closed suddenly and with it the purchase of Gebouw 13 stopped. Unfortunately the Brouwcie does not yet have a way of storing large quantities of beer in the fridge (Rosa?), so the beer was on a course to expire before the university would open its doors again. Mix some boredom, nice weather, a few Gebouw 13's down my throat and six crates that are about to expire and a delivery service is born. On my noble steed I set to deliver beer to your door, fitting a whopping 29 bottles in my backpack. I enjoyed the small talk at every door just as much as the ride but still hope that we can crack one open together again. The Brouwcie is able to brew (and barbecue) again, so expect more beers during the coming year! And remember **MORE BOTTLES = MORE BEER!**

Sibren Wobben:
So far it hasn't been a very fun to live with the lockdown, however there might be a positive side to it: It has been a weird time, but there is definitely something to learn! Francken has had some of its most unique activities which might even turn into regular events in the future! It was also surpising to see how many people showed up to our online symposium (especially since there weren't any *kroketten*). And, although we had to work through months of corona, it somehow still feels like I just blinked once and we were already sitting in the T-GMA. We're all going to remember this period in time, but hopefully we'll also remember all the great and unique moments these strange times has brought us.

Tabitha Minett:
The lockdown coincided with the beginning of our candidate period, so we had to do much of our learning from the comfort of our own homes. This period raced by, and before we knew it we were being hammered in. I've been lucky enough to have Pluis keep me company since the GMA, and with the Francken canteen in my hallway, I feel like I have a bit of Francken at home. Although I could fulfill some of my duties online, I eventually had to go to Francken to *try* to send edition 24.1 (I emphasise "try" as I was not entirely successful). An empty Franken room is very strange, and I look forward to the day we can hang out together after corona.

Francken Abroad

By Chantal Kool

September last year, I exchanged Groningen for Edinburgh and moved, with my whole life in 3 suitcases, to Scotland. As someone with a deep love for the UK and the desire to go abroad, I was very happy to find out about the MSc "computational applied mathematics", which embodied everything I was looking for in an MSc at a competitive British university. At the moment of writing, the exams of my second semester are just around the corner and after that only my dissertation is left; the year went by quicker than I could have imagined. Keep reading if you want to know how different studying in Groningen is from studying in Edinburgh!

Edinburgh is the capital of Scotland, has around half a million inhabitants, and is the birthplace of Harry Potter, which makes for a very different scenery than Groningen. The "*ouwelullen*" who went on Buixie 2014 know how incredibly beautiful the city is, every walk through the city keeps surpri-

sing me with new hidden gems and being able to have weekend trips to the highlands is an amazing gift. This all sounds like I've been having one big holiday, but let me stop you there. As the University of Edinburgh is very competitive, I feel like I have learned more already than in two years of my bachelor and have worked thrice as hard. My MSc is structured in such a way that I have 2 semesters and a dissertation in 12 months, the first semester ends just before Christmas (so no studying during the Christmas break, 'vo), the second one at the end of May and then you have 3 months to write your dissertation. Because this MSc is 12 months whereas in Groningen it is 2 years, you can imagine free time is very sparse.

Student life in Edinburgh is quite different from student life in Groningen. We all know each other because of our beautiful study association, but study associations are (almost) non-existent in Edinburgh and the focus is much more on sports and their corresponding clubs. Besides sportsclubs, there is a tremendous amount of (weird) societies, all with a different focus, to name some: the gin society, League of Legends society, trading club, wine society, Muggle Quiddich Fan Club... Your social life mainly revolves around your club or society.

I joined, among others, the motorsport club as a big fan of Formula 1 (F1) and quick vehicles in general, since the UK is basically the birthplace of F1. There is a British Universities Karting Championship where all British universities compete on famous tracks throughout the UK, jolly good fun! Although I am convinced that the British are pretty good at consuming alcohol, the drinking culture from the Netherlands is not very present in (postgrad) UK student life. My liver is probably still confused about what happened the last 2 years going from a Francken board year to Edinburgh postgrad life where I didn't even join the wine or gin society (out of self-protection).

Another big difference is that in the UK, you barely find students older than 23. Where the Netherlands is known for its "*eeuwige studenten*", in the UK you maybe take a gap year after high school, do a BSc and go to work at the age of 21/22. Since the tuition fees are so high (except for the free BSc in Scotland, if you're a European non-English student), studying longer than necessary is very undesirable. Doing an MSc is not nearly as common as in the Netherlands, where an employer may start asking questions when you only did an undergraduate degree. Also, since the academic year only consists of 2 semesters, the summer break in the UK is very long and a lot of students use this to get into one of the many competitive summer internships to distinguish themselves when hunting for jobs and to get some money (the internships pay quite well). This money is easily spent, since living in the UK, and especially Edinburgh, is very expensive with sky-high tuition fees, higher beer prices than the streep syteem and crazy expensive housing.

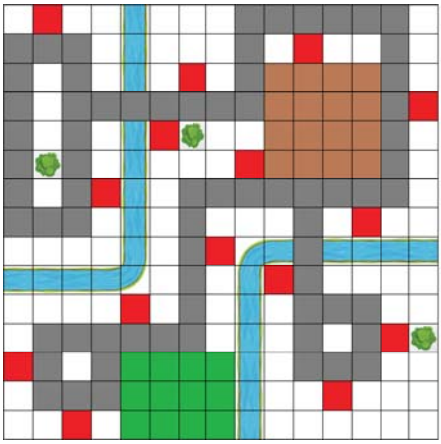
It has been an amazing year where I met a lot of new amazing friends, learned and studied a lot, was in the middle of history with both Brexit and Covid-19, but most importantly, had 0 regrets of making this decision. If you are ever in the neighbourhood of Edinburgh and want to have a cup of tea together or want to know more about studying in the UK, just drop me a message!

Puzzle

By Arjen Kramer

For this edition of the Francken Vrij, I'd like to present you with a little present that I constructed. With the Corona crisis, I have had some time to look around the interwebs for different puzzle types and I found out that in the logic puzzle scene: **A "coral" is considered to be a collection of shaded cells, that form a single orthogonally connected region, that does not enclose any of the empty squares, and no 2X2 area may be completely shaded.** *Here is the solution to the last puzzle:*

With '**Coral**' also being the material connected to a **35 year anniversary** and thus the present Lustrum year, it seemed appropriate to make use of this in the puzzle. And with some time on my hands I may have put in a bit too much effort and completely made these puzzles from scratch, so the difficulty is rather difficult to judge. Still, as I'm learning about making puzzles, I would love to hear your comments/(contructive) critisisms on my puzzles via: *arjenkramer@hotmail.com*



Roads are grey
Houses are red
Town square is brown
The park is green

On the top left, we have a *Classic* coral puzzle (similar to Japanese puzzles):
Draw a '*Coral*' in the grid. Clues outside the grid indicate the lengths of connected shaded cells in the corresponding row or column. Clues are given in increasing order and **not necessarily in the order the blocks appear**. There must be **at least one white cell** between two blocks of black cells.

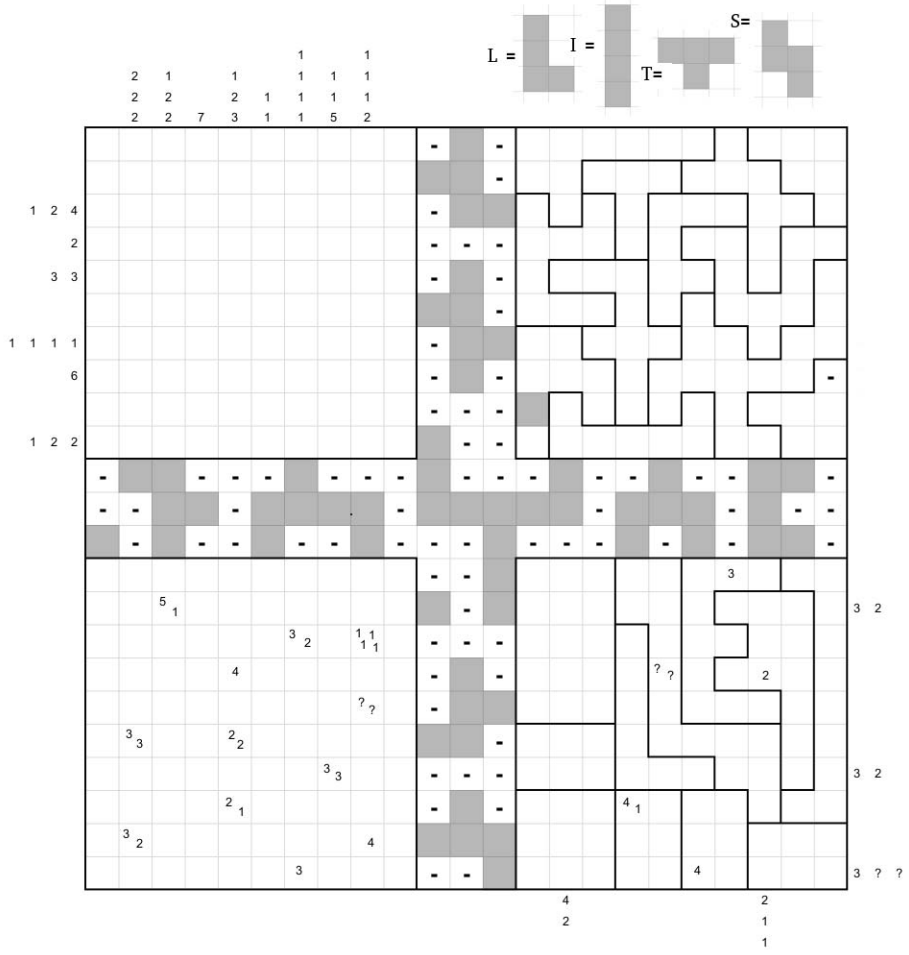
On the top right, we have a *LITS* variant coral puzzle :
Draw a '*Coral*' in the grid. Every bold outlined area contains **exactly one** of the 'LITS' shapes, which are shown next to the puzzle. Two shapes of the same type are **not** allowed to touch. The shapes can be rotated and/or mirrored.

On the bottom left, we have a *Tapa* variant coral puzzle:
Draw a '*Coral*' in the grid. **Clue cells remain empty** and indicate the length of each consecutive block of shaded cells in the eight surrounding cells. When there are more clues in one cell, the blocks indicated by different clues must be **separated by at least one unshaded cell**. (I don't know where the name 'Tapa' comes from, but slightly begind 'Starbattles', 'Tapa' is my favorite puzzletype, so please look them up sometimes).

On the bottom right, we find a '*Coral*' puzzle which combines all these variants, so all of the rules apply.

Question marks, can stand for any digit and some cells have already been marked as shaded or empty. Each of the four corners of the 'present' can be solved (mostly) on their own, though the overall, unique solution is only found by looking at the complete puzzle and making sure that, together with the shaded cells in the middle region, the puzzle forms one 'Coral' shape.

The first submission of a correct solution will be given a 2X2 Rubiks cube. Not as difficult as a 'real' one, but you also won't get the recognition of being able to solve a 'real' one. **Amazing!**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Meet your ASML Campus Promoter David Homan

You may have seen the ASML logo around the University of Groningen. You may wonder what kind of company ASML is and what potential careers it has to offer. But what you may not know is that there is someone on your campus who can answer all your questions and more – ASML student campus promoter David Homan.

So, tell us more about David Homan?

Hi, I'm David, I'm 24, I'm in my fifth year, studying for a Bachelor's in Artificial Intelligence. Five years sounds like a long time to be studying, I know. But I started out in two other interesting fields, philosophy and law, before finally ending up at the study I'm most passionate about. I find a lot of things interesting - outside of my studies, I enjoy everything from reading to learning new languages, from playing the drums to kickboxing, from computer games to card games – right now, my new favorite is Texas Holdem poker!

You're also a member of study and student associations. Is that how you got to know ASML?

That's right. I was on the board of 'Cover', the study association for the Artificial Intelligence and Computer Science. Board members from university associations from across the country get invited to special 'board days' at ASML, and I was lucky enough to go. I was super impressed. It wasn't just how high-tech it was or the jobs on offer. What was most impressive was the feeling of freedom and dynamic creativity. It's an exciting place, and importantly, it's a company that respects its people. When later they were looking for a campus promoter for our university, I was happy to sign up, and proud to represent ASML.

ASML

Be part of progress

What can students expect from you as an ASML campus promoter?
First and foremost, I'm here, anytime, for any questions you have about jobs and life at the company, scholarships and internships, and much more. We can arrange a meeting, but equally (and as I often prefer!) you can chat to me wherever you find me - I'm always enthusiastic to talk about ASML. Beyond that, what I like about the role is the freedom ASML gives me to make it my own – to think of my own ways to reach out to fellow students. But also that the focus is absolutely not on 'headhunting'. I'm not here to recruit you, I'm here to help you understand the company, so you can make more informed choices when it comes to your career after university.

Finally, what other career advice would you give your fellow students?
Don't be too focused on your academic results! Just as important is your personal development. I didn't have the best academic results, but I've made certain I've never stopped developing myself in all the areas that interest me. If I'm passionate about something, focus and fulfillment will follow – and that's much more important than high scores alone.

Put your study to work
We welcome students from all over the world to join us for internships and graduation assignments at our global headquarters in Veldhoven, the Netherlands. Want to see what's possible? Gain hands-on experience and support with ASML scholarships or attend a career event for students and PhD graduates. Learn more at **www.asml.com/students**.

You can get in contact with David via david@workingatasml.com!

Present

By Jelle Bor, MSc

In your childhood, your family or friends have most certainly asked you if you knew what kind of profession you wanted to do later. There are a lot of choices, but most children logically choose one of the following: Dancer/Choreographer, Actor, Musician, Teacher, Scientist, Athlete, Firefighter, Detective, Writer, Police Officer, Astronaut, Pilot, Veterinarian, Lawyer, or Doctor. Of course these are all cool jobs, especially if you were to be a Scientist. Nevertheless, here we are now, in the present, and I don't think many of you have followed the path of your former dream job (although you probably made an excellent decision to study Physics). In the present, we're working towards a job, studying to pass an exam, or busy getting a project finished. But by the time we get to where we want to be, we'll be in the future, and we'll have something else we want to do or must achieve. We are in the same situation as before: stuck in the present. It is logical therefore, that some people live with a mindset of '*carpe diem*', and most of us sometimes think that it would be great to be (a few years) younger again, to go back in time to do things differently. You make particular decisions during your life about what you want to do, which makes the present on the one hand very evident, but on the other unsure, since your present decisions will determine your future. Therefore, it is natural to ask yourself questions such as: *Where will I be in x years? Why did I choose to study Physics? When will the COVID-19 virus be banished from our world and is a vaccine or a group immunity the solution? Are 5G and corona connected? (No, they are not.) Will the new board be good for the future of Francken?*

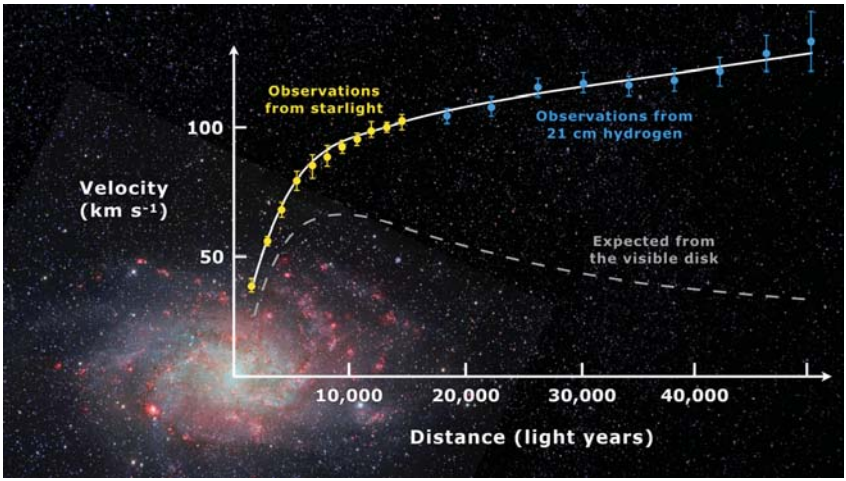


Figure 1: Rotational speeds of the spiral galaxy Messier 33.

In the last Francken Vrij we took a dive in the history of the Universe. We found out that the Universe is presently dominated by dark matter and dark energy. In this article we are going to look into possible solutions for these mysterious things. To recap, dark matter produces an attractive force. The most famous experimental and first evidence of dark matter were velocity measurements on flattened spiral galaxies, such as our own Milky Way galaxy. The velocity measurements were made on clouds of hydrogen gas visible in the outermost regions of the spiral galaxy, where no starlight is produced. With the known gravitational laws, the required mass was calculated from the measured rotational speed of the flattened systems. This mass was much larger than the total mass of visible stars and gas clouds. In other words, the outer regions of the spiral galaxies rotate faster than expected on the basis of the known mass (as in Fig. 1). So there must be a stronger gravitational field. Therefore, it is thought that there is invisible (emitting no electromagnetic radiation that reaches Earth) mass in the spiral galaxies: dark matter. Data from these rotation curves indicate that about 90 percent of the mass of a typical spiral galaxy must be dark matter. In addition, dark matter should be likely diffuse and does not clump on the scale of solar systems, i.e. there are no dark matter celestial objects that have local gravitational effect. Moreover, there is another mystery as it appears that there is no dark matter in elliptical galaxies.

There are more evidences of dark matter having impact on the Cosmic Microwave Background to large scale structure formation and galaxy clusters.

Dark matter

Dark matter is detected through its gravitational interactions with ordinary matter. As such, it is very difficult to determine what the constituents of dark matter are, since it is not something you encounter in daily life. There are multiple candidates for dark matter. The first candidate is just Baryonic matter, ordinary matter like protons and neutrons, but in ways we cannot observe them. Specifically we mean Massive Compact Halo Objects (MACHOs): large, condensed objects such as black holes, neutron stars, white dwarfs, very faint stars (Brown dwarfs), or non-luminous objects like planets. The search for these objects consists of using gravitational lensing by detecting the effects of light from background galaxies. However, calculations indicate that there may not be enough baryonic matter to explain all dark matter, due to the nucleosynthesis in the young universe: the abundances found of the various elements and isotopes cause quite strict limits on the density of the baryonic matter in the young universe. The second candidate is cold dark matter or WIMPs (Weakly Interacting Massive Particles): hypothetical particles which only interact via gravity and possibly the weak nuclear force or unknown forces that 'ordinary' matter does not feel. Many candidates have been proposed over the years such as axions (these are light particles, in contrast to what I just mentioned, but with a specific type of self-interaction that makes them a suitable as 'cold'): hypothetical particles originally introduced to resolve the strong CP violation problem (charge in combination with parity are not necessarily conserved, but no violating reaction has been observed in experiments in quantum chromodynamics); or neutralinos: these are predicted in supersymmetric models. Maybe it's an even more exotic form of matter. The third candidate is *hot dark matter,* which consists of - in contrast to cold dark matter - light mass particles. An obvious candidate for it is the neutrino, which has a small mass (which we don't know precisely, only an upper bound), and would exactly meet the conditions for hot dark matter. However, a model with only hot dark matter is not sufficient. Hot dark matter is much less likely to clump together (form density variations) than baryonic and cold matter. Therefore, if all non-baryonic matter were hot, there would be insufficient clumping to explain the formation of galaxies on the large scale structures. Hot dark matter is therefore, always discussed as part of a mixed theory of dark matter, and therefore, cold dark matter is the most popular candidate.

Another way to describe dark matter is to use *alternative gravity*. Not to be confused with alternative medicine, which is not ma-

thematically proven to be successful. If we focus on the determination for the need of dark matter in spiral galaxies, we could assume that the gravitational forces are larger than Newtonian gravity at large distances. This can be done by assuming that the cosmological constant in general relativity is negative.This value however, quantum mechanically the energy content of the vacuum, is believed to be positive based on recent observations. Another idea is to change Newtonian mechanics, by changing for example the gravitational potential as:

Which returns the well-known potential in the *Newtonian Limit*. This approach howe-

$$U = \frac{Gm(1 - Be^{-r/\rho})}{(1 - B)r} \quad \overset{B=0,\ \rho\to\infty}{=} \quad \frac{Gm}{r} \qquad (1)$$

ver, as well as similar ones, leads to difficult explanations of the different behaviours of the different galaxies, while they are easy to describe by assuming different amounts of dark matter.

Dark energy

Dark energy works, in contrast to dark matter, as anti-gravity and is isotropic and homogeneously distributed in the universe. Albert Einstein had already introduced in 1917 a cosmological constant in his field equations of general relativity, to prevent the universe from collapsing by gravity according to the then accepted theory of a static universe. After discovering the expansion of the universe (Hubble's law ex-

Figure 2: The Particle Zoo sells cuddly toys for Physicists. Could you embrace dark matter?

plains the red shift of light spectra of far away galaxies by the Doppler effect: they move away from us), Einstein withdrew the idea of this anti-gravity and called it, well known, 'his biggest blunder'. In the 1990s, the study of distant supernovae discovered that the expansion of the universe accelerated around five billion years after the Big Bang. The only way to explain acceleration was to introduce an unknown force that behaved like a cosmological constant and acted like negative gravity.

Space doesn't change its properties as it expands, there is just more of it. Therefore, dark energy seems to be energy intrinsic to empty space, driving the acceleration of the Universe. There are multiple ideas about what dark energy might be. One proposal is that this energy is an intrinsic property of space, and as more space is constantly

being generated this accelerates. This can be understood as Einstein's cosmological constant, but our theoretical understanding predicts a cosmological constant that is a power of 10^{120} larger than what we measure. Another idea is that empty space is full of temporary virtual particles that are spontaneously and continuously created and annihilated (which can happen due to Heisenberg's uncertainty principle). The energy from those particles could be dark energy. Other theories are out of the scope of this article, but all remain to be proven. Presently, state of the art observations have found that the Universe consists for 68.3% of dark energy! The dark matter content is a phenomenal 26.8%, and the leftover, 4.9%, is baryonic matter. Making us even more insignificant in the scope of the universe.

Hopefully you are well on your way of your present-day dream job, or you are doing good if you don't know where the future will bring you. Next time one of your elderly family members tells you that 'everything used to be better' instead of asking what you wanted to become (one of those present-day situations), you can agree that in some sense they are right. Although, they are probably talking about their youth and not about the time we didn't know about the present problems of dark energy and matter, when life was more apparent.

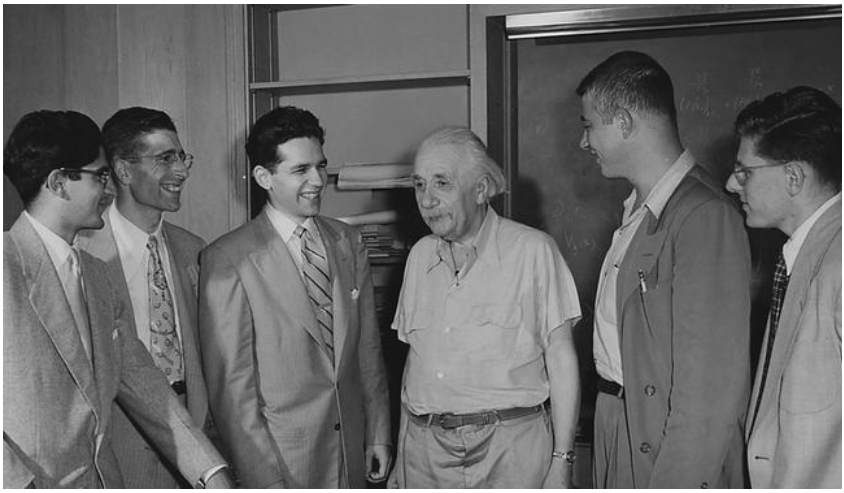


Figure 3: Albert Einstein with his students at Princeton in the early 1930.

Mathematical modeling of COVID-19

By Paul Wijnbergen, Ir.

With the world turned up side down due to the COVID-19 virus, what else could we expect from the Francken Vrij than providing us with some Corona related article? And what do you do, when there is no interesting enough (applied) physics related to this virus outbreak? Indeed, you start paying attention to what is in a physicists opinion the second-best thing, the mathematics behind it. Although I am not an expert on the mathematics involved related to Corona at the moment, I have some idea of what is going on and what is interesting to talk about.

Nowadays scientists at; for example, the RIVM are trying to understand how the virus spreads, how fast it spreads and what the consequences are. Hence they start to collect data on how many people get sick, what the sources were of an outbreak, how many people die etc. Then they start thinking of some theory that could explain all this data, which usually results in a mathematical model. Such a model is never perfect, but if it predicts the future sufficiently well, people are in general happy. If it turns out that we can influence the future of this virus outbreak by means of applying some input, applied mathematicians are more than happy to give some advice on what kind of control to apply.

So, just for the fun of it, let's try to model some of the virus ourselves. First of all, we need to come up with some variables. Say that we live in this world with a population of size N. Of this population, we can assume that an S amount of people are susceptible to the virus. Then due to the virus, I people are infected with COVID-19, however,

R people have already recovered. Some recovered people can get infected again after some time which means that it is reasonable to argue that the amount of susceptible people will change as a function of the amount of infected people and recovered people. The amount of infected people should depend on the amount of people that are already sick and similarly the amount of recovering people should depend on the amount of infected and recovered people.

This leads to one of the simplest possible model for a virus outbreak: the SIRS model, given by (1). In this model β is how many people are infected on average by a sick person, and γ is the rate at which people recover and ξ is some variable that serves to model after how much time a recovered person can get infected again.

$$\begin{aligned} \frac{d}{dt}S &= -\beta I\frac{S}{N} + \xi R \\ \frac{d}{dt}I &= \beta I\frac{S}{N} - \gamma I \\ \frac{d}{dt}R &= \gamma I - \xi R \end{aligned} \tag{1}$$

A quick sanity check, reveals that the total population $N = S + I + R$ remains constant. That is

$$\frac{d}{dt}N = \frac{d}{dt}(S + I + R) = 0.$$

This means that according to this model we have three scenarios. We could all get infected or we could all recover. Or we end up in the situation that the same amount of people get sick as the amount of people that recover. The outcome depends of course on the values of β, γ and ξ. Intuitively this makes sense as well. If a virus is very infectious, then β is very large and we will likely all die. But if β is very small and γ relatively large, we might just survive. Alright, we have some model. But what can we do now? We do not know what the values of β, γ and ξ. One could even imagine that these parameters are not constants, but some (possibly nonlinear) functions. However, this does not mean that we cannot do anything. Because we can do two things. The first thing that we can do, is collect as much data as possible. From this data we can then make estimates of our parameters. This sounds very easy, but in practice this is quite difficult. It is actually really hard to find good data. A lot of data is biased data and therefore, not so useful for parameter estimation.

As an example, one could keep track of how many people test positive for the virus in a country and conclude from that data that people who are sneezing a lot, are more likely to test positive. But if the majority of these tests are done in spring, when most people with 'hooikoorts' are sneezing anyway, what can you really conclude form this data? Furthermore, collecting data takes time, and when a virus is spreading, we usually like to prevent the outbreak, instead of having one for the sake of good data. So, what was this second thing we can do? We can take measures which are likely to

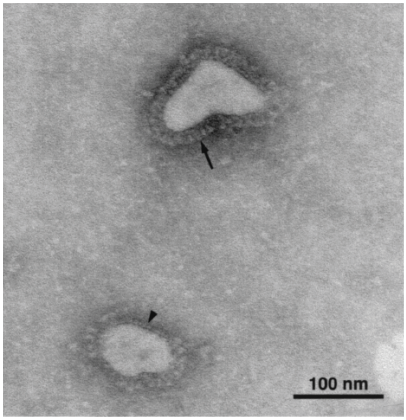


Figure 1: Coronavirus particles (80 to 120 nm in diameter) identified in in- fected HRT cell supernatant fluids.[1]

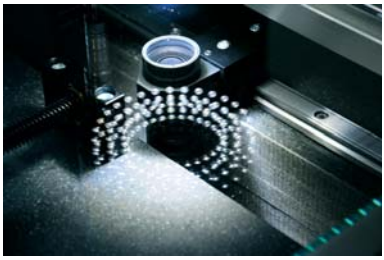
influence these parameters. This is exactly what is going on. First of all, we keep this 1.5 meter distance. We assumed that the COVID-19 virus is spreading via relatively large particles that leave our body via the mouth and nose. These particles are likely to fall down within a meter distance from our face, and hence 1.5 meter distance between people should lower the β considerably. Secondly, we try to obtain as many available IC capacity as possible and if you are able to find a vaccine you will probably never have to work in you life ever again. In the perspective of our model, these measures boil down to increasing the value of this γ. If you think about the model and the measures that are taken, I am pretty sure you can link them in one way or another to each other.

A lot of you are also probably thinking, this model you introduced is over simplified. It sounds like a lot of bullshit to me! I guess these people are right on some points. The model is very simple. But feel free to increase the complexity. We can; for example, make the population size variable and introduce a parameter for the amount of deceased people. One can even introduce statistics in to the model by making it a stochastic system. There are a lot of ways this model can be made very very complex. And for real, if you are interested, there is a lot of research on the modeling of COVID-19 or in the system theoretical behavior of a virus in general going on. All of a sudden there is a lot of money available for PhD students and research in general, so not only for people who study medicine and pharmacy are there research areas arising.

Since most readers of the Francken Vrij are still applied physicists, I won't go into much more detail regarding the mathematics. So here ends my story on mathematics and corona. If you would like to know more about this modeling, I would recommend you to take the course Control Engineering, or if you are really interested take Systems Theory and Advanced Systems Theory. This will give quite a good idea of how to do this. Stay healthy y'all.

References

1. Guy, James & Breslin, Jamie & Breuhaus, Babetta & Vivrette, Sally & Smith, Lynda. (2001). Characterization of a Coronavirus Isolated from a Diarrheic Foal. Journal of clinical microbiology. 38. 4523-6. 10.1128/JCM.38.12.4523-4526.2000.



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