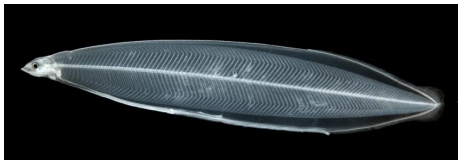
Periodiek

Recurring at regular intervals Issue 2026-1



8 - The Eel Enigma

It has been long debated and research how and where exactly eels reproduce. Dive into this topic with our friends from GLV Idun's Lifeline to find out more about this slippery topic.

Perio Interview: Marcos Guimarães - 12

Every issue of the Periodiek, we ask a lecturer one important question. *What did you have for breakfast?* This issue we've interviewed Marcos Guimarães to get to know him.

23 - KBE '25

Roughly this time last year, a group of FMF members went on an exciting excursion throughout Europe, visiting Copenhagen, Hamburg, and Lund. Luckily for those of us who stayed home we can read about all their scientific visits and get some glimpses into their experiences during the trip.

In this Periodiek

From the Editor in Chief

While we all enter the last block of this academic year, the editors of the Perio*diek* are happy to publish our latest issue. In this issue we are bringing back the "In the News" section of the Perio*diek* as well as a bigger Art Section than usual. If you have any artistic works you would like to showcase to the rest of the FMF, shoot us a mail!

The highlight of this issue is a text by Milene about Émelie du Châtelet, who famously translated Newton's Principia Mathematica. This text was originally written as part of the Master course 'Mathematics and its Environment', which we will hopefully have more collaborations with in future issues.

I hope you all manage to hold out these last few weeks until the summer break and pick up the Perio*diek* during your moments of procrastination.

Robert Mol

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In the News

AUTHOR: **A. NIJLANT**

For the past couple months, I have been screaming around the FMF room that since October last year, a subscription to some Dutch papers is free for students between the ages of 18 and 25. I thought why not put this to its full potential and take the initiative to write some scientific news in the Perio*diek*.

A New Galaxy

Astronomers have just discovered one of the most mysterious objects ever seen in the nearby universe: an almost entirely invisible galaxy dominated by dark matter. The object, called Candidate Dark Galaxy-2 (CDG-2), lies roughly 245–300 million light-years away in the Perseus galaxy cluster. It was identified not by bright stars, but by a tight grouping of four star clusters. Dense swarms of old stars that act like cosmic "breadcrumbs" pointing to something hidden behind them. What makes CDG-2 so remarkable is its almost complete dominance by dark matter. Observations combining data from the NASA/ESA Hubble Space Telescope, the ESA Euclid mission, and the ground-based Subaru Telescope in Hawaii revealed a faint, diffused halo of starlight surrounding the star clusters. It is evidence that there is indeed a galaxy there, and it is one with very little ordinary matter. Preliminary measurements suggests that CDG-2 shines with the combined light of only about 6 million suns, with the four globular clusters responsible for about 16% of that visible glow. Most of the "normal" material usually found in galaxies, particularly hydrogen gas that is needed to form stars, appears missing. It was likely stripped away by gravitational interactions with other galaxies in the crowded Perseus cluster environment. Without much gas or stars, CDG-2 is nearly invisible, earning it the nickname of a "dark galaxy."

Yet, despite its faintness, its total mass is dominated by dark matter to an extraordinary degree, with estimates placing the dark matter fraction at around 99% or more of the galaxy's total mass. Because dark matter does not emit or absorb light, it can only be studied indirectly through its gravitational effects on visible objects, like stars and star clusters. Galaxies like CDG-2 thus serve as natural laboratories for understanding how dark matter influences the assembly and evolution of cosmic structures, from tiny star clusters up to enormous clusters of galaxies spanning millions of light-years. In addition to deepening our understanding of dark matter's role in shaping the universe, this discovery highlights how clever observational strategies, such as identifying galaxies via their globular cluster populations, can reveal objects that would otherwise be invisible.

Physics in the Winter Olympics

Since before the Winter Olympics in Milan this year, rumours have already started spreading that some ski jumpers have artificially enlarged their crotch area while getting their suit fitted. The purpose of this is that they can have more fabric over that area, which will better help them fly through the air. This escalated quickly and is now called a "penisgate" online.

How does this work? And does it really give a higher chance of winning? The short answer is yes. Before getting into the why's and the how's, we need to know a little bit more about the jumpsuit that ski jumpers wear. Ski jumpsuits are precisely tailored to the jumper's body. Before the event starts, the ski jumpers are 3D scanned to make these suits. This is important as the playing field will be equal among the contestants. What happened is that some ski jumpers got their penis injected with hyaluronic acid, a substance that is also used in plastic surgery. After this injection, they are again 3D scanned. After a while, the swelling reduces as the body absorbs the hyaluronic acid, thus giving the athletes some more space in their suits at the time of competition.

Now we can get into the physics of this. In ski jumping, the athlete converts their gravitational potential energy into forward speed and aerodynamic forces to maximise flight distance. A ski jumper begins by descending a steep ice ramp, minimizing friction and air resistance to reach speeds around 95 kilometres per hour before take-off. At the end of the jump, they launch into the air and because they are moving through the atmosphere, their motion is governed by gravity, lift, and drag. In a vacuum, the optimal launch angle should be 45°. However, we are in the air, so ski jumpers can exploit the aerodynamic forces lift and drag. To produce lift, the object (in this case the ski jumper) must be moving through the air and have its surface colliding with air particles and pushing the particles out of the path. According to Newton's Third Law, action equals opposite reaction, as

air particles are pushed down, the object is pushed up. The object being pushed up by air particles is what is called lift. This increases the speed as well as the surface area. For ski jumpers, it is important to position their body to maximize lift while reducing drag as much as possible. Even tiny changes in the jumper's shape or suit can affect aerodynamics. Adding just one centimetre to the circumference of a ski jumper's suit can increase jump length by several meters because it increases the effective surface that interacts with air flow. This produces more lift and less drag, a valuable boost in a sport decided by centimetres.

Figure 1: A Ski Jumper

Old Topology Problem Solved

For over a century, mathematicians wondered: Can certain highly twisted geometric objects exist that satisfy both curvature rules and topological structure rules at the same time? The answer is yes! We already know that this exists for surfaces in two dimensions, but now we have also found that it works for higher dimensions.

The idea is that by measuring particular distances and angles, for example, on the ground of the Earth, we can determine that the Earth is a sphere and not flat or doughnut-shaped, without using a satellite. For decades, researchers studied manifolds under specific curvature constraints. Theory suggested two possibilities: Maybe geometry forbids complicated topology, or maybe exotic examples exist, but nobody could construct them. The obstacle was that analytic techniques predicted limits, but no explicit geometric models were known. So, the question remained unsolved for over a century.

Mathematicians have now constructed two concrete manifolds with carefully engineered twisting. Combining tools from geometric analysis, controlling curvature very precisely, assembling local geometric pieces into a globally consistent space. The resulting spaces satisfy the required curvature conditions yet posses unexpectedly rich topology. In short, geometry does not prevent complicated topology; these twisty shapes really exist. In 1867, French mathematician Pierre Ossian Bonnet proved that a surface is usually determined by its metric and its mean curvature. However, later mathematicians found exceptions, some surfaces share the same metric and mean curvature yet are globally different shapes. These counterexamples all turn out to be non-compact surfaces, surfaces that extend infinitely or have boundaries, unlike compact surfaces such as spheres or doughnuts that close up neatly.

Alexander Bobenko has spent a couple of years on discrete surfaces. To get a discrete surface, we can take a finite collection of points and connect them by lines to form a shape with flat faces. By choosing different points, there are multiple ways to represent these discrete surfaces.

In the 2010s, doctoral student Andrew Sageman-Furnas revisited the Bonnet problem in this discrete setting. Inspired by woven fabrics like fishing nets, he asked when local information uniquely determines a discrete surface. Together with Max Wardetzky and Tim Hoffmann, he found methods to create discrete counterexamples, but they were always non-compact. Because discrete surfaces can be studied computationally, Sageman-Furnas wondered whether a compact counterexample might exist. As a postdoc in Berlin, he launched a computer search in 2018 for a torus-shaped "starter" surface capable of generating Bonnet pairs. After months of work, he discovered an unusual, spiky object nicknamed the "rhino." Despite its strange appearance, the computer suggests that it was a torus that produced compact Bonnet pairs.

The discovery was exciting but uncertain: numerical rounding errors could have created an illusion, so the team needed rigorous mathematical proof to confirm whether the result was real. Drawing on century-old formulas by Jean Darboux, they modified them so the curvature lines closed, producing smooth tori with the same metric and mean curvature but different global shapes. After refining the construction, they generated a striking pair of twisted, self-intersecting tori, showing that even compact surfaces like tori are not uniquely determined by local geometry. The result highlights how discrete surfaces can inspire breakthroughs in smooth geometry.

From the Board
Commissioner of Educational Affairs

AUTHOR: **I. ANTONACHE**

Hi lovelies, I am Ilinca, your Commissioner of Educational Affairs! Although I have endlessly many exciting things to talk about, and only so many words I can write in the Periodiek. But fear not, for I am always open to a short (or better, long) chat!

Aligned with popular expectations, I did my homework prior to writing these words, by reading through all past "From the Board" sections and taking notes here and there; and still, I am writing mine well past the deadline. I do believe, though, that it is not a proper Board task if you don't do it chaotically.

However, I can promise my other duties are completed in a ~~slightly~~ much more careful way. Emails to professors and alumni are sent on time, TAs are always secured for the Practice Sessions, rooms are booked (and sometimes double-booked) for the events, and the beverages are ready to be served hot at the Coffee Mornings. I also like to make sure that my calendar, although at times so full that it is impossible to read the title of the events anymore, is color-coded in the prettiest way possible. Surely enough, if you are patient, you can spot the red blocks reading "EXAM". I will admit there's plenty of them, as this year marks my third year of bachelor studies in Mathematics and Physics. If there is one thing my degrees taught me, it's that grades and percentages don't matter, except for when it comes to alcohol.

When not adhering to a schedule, I fill my time with other things that I love. In no particular order, this includes caffeine, tiramisu, and a certain supermarket chain. Curating music playlists and playing the New York Times games are also up in the top, next to thrifting a new skirt and grieving about the lack of skirts to thrift. But most of it all, I enjoy talking to people; many of my friends are studying a wide range of things and there is always something new to take from their experiences. Even if there is nothing to learn, there is something to complain about.

Of course, my fellow Board members are part of this nice group of people. I figured out my official/formal role in the team, but I have also been voted the mom, the one most likely to go to jail, and the audience entertainer, all in the span of one month. Curiosity killed the cat, but I still can't wait to see what the last part of the year will reveal.

"Even if there is nothing to learn, there is something to complain about"

As my morning alarm is about to go off, I guess it's time to wrap this up. The end of the day usually finds me on the burgundy couch in the FMF room, talking to my friends and judging the music on the aux. And probably, per the Edu's tradition, I'm enjoying a chill beer and thinking about the next one. At any time, feel free to join me!

Yours academically, Ilinca.

Figure 2: Ilinca

The Eel Enigma: How eels come into existence

Exchange article

AUTHOR: **V. SCHULTE**

Eels are incredible creatures. They took the body plan of a fish, but removed the scales in favour of slimy skin, and elongated their body to allow themselves access to food and shelter that other fish can't reach. Moreover, these creatures have puzzled scientists for millennia, and it's not even for any of the reasons listed above. Instead, for the majority of human history, the big question about eels was pretty simple: where do they come from?

Even as far back as 350 BCE it was noted by philosophers like Aristotle that the eels in European waters lacked reproductive organs. Thus, he concluded that all eels must be neither male nor female, and "can engender nothing". As for how they actually come into existence, Aristotle had a theory. He'd observed that when a dry pond is refilled with rain water, eels appear in it. Thus, he concluded that eels are actually earthworms being transformed by the rain.

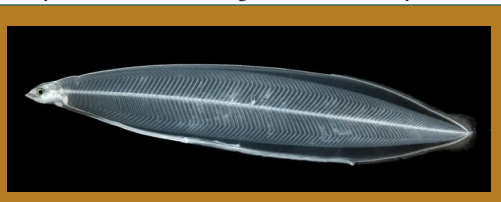

Figure 3: The larva of an eel is transparent

Similar theories of "spontaneous generation" remained relatively unchallenged for centuries, barring the specific method of creation. It wasn't that a breakthrough was made, when Carlo Mondini discovered that specific frilled tissues in a particularly large eel were not fat tissue, but ovaries. Still, the obvious follow-up question remained, as the male counterpart had yet to be found.

Almost a century later, in 1876, a budding scientist enters the fray, looking for the elusive eel penis: none other than Sigmund Freud. He spent an entire summer in Trieste dissecting over 400 eels in search of the reproductive organ, but much to his frustration, he was unable to find them. Some people, including one of Freud's close friends, suspect this triggered some of the sexual anxieties that would become a central part of his future work in psychology.

The mystery was solved just a decade later, by accident. Zoologist Yves Delage had been keeping a marine species then known as Leptocephalus morrisii. One day, Delage observed that his leptocephalus had transformed into a glass eel, and after keeping it for a while longer, into a conger eel. All of these animals were known already, but Delage had learned that they were actually all one and the same: eels must undergo metamorphosis.

The final major "Eel Question" was now the location of their spawning grounds. Danish biologist Johannes Schmidt set out for well over a decade to find where in the Atlantic the leptocephali were smallest, and narrowed it down to an area known as the Sargasso Sea, a large oceanic gyre east of Florida. We now know that both the European and American eels spawn here, but the details are still vague, as mating has never been observed. The only thing we know for sure is that this is where mature eels go at the end of their lives, and little baby eels start their Odyssean migrations.

Figure 4: The Sargasso Sea: the eel spawning ground

Money-Pump Arguments
Philosophy Section

AUTHOR: **I. ANTONACHE**

Suppose that, on a warm day of spring, you find yourself on the FMF couch, in need of a beer. Also, suppose that you can't tell the difference between the effects of one or two beers (reasonable enough), and that, when you are given the chance, you would prefer having less alcohol (for health reasons). But also, due to your passion for beer, you would *for sure* prefer three beers instead of one!

Let X, Y, and Z be the prospects (for now, think of the intuitive meaning of the word only) of having a beer, respectively, two and three. Then, you prefer X to Y, Y to Z, and Z to X; in other words, your preferences are cyclic.

Let us adapt this scenario a bit. Suppose now that you want to buy a beer (scenario X) and your good friend reminds you that you would like more beer rather than less (scenario Z), so you pay for two more beers. However, your other friend reminds you of the promise you made of drinking less; so, you gift each of them an extra beer, and you're left with two. Unsatisfied with the hydration level, you're also getting yourself an alcohol-free drink (scenario Y). But now you've lost your bought beers, and your last money! (This is a variation of Dummett 1984; for a similar situation, you can look up the Condorcet paradox).

So, how exactly did this happen? Easy enough, your cyclic order of preference for scenarios X, Y, and Z, seemingly irrational, allowed for your exploitation.

This toy model is an example of a money-pump argument. A money-pump argument purports to show that intuitive requirements of rationality are indeed necessary in decisions taken by otherwise rational agents; in other words, were we not to follow these "rules" of rationality, we would end up paying for something we could've kept free from the beginning (hence the name of money-pump).

These rules are also known as the axioms of rationality within a given framework or theory. The most popular of these theories is the Expected Utility Theory (EUT), of von Neumann and Morgenstern (in literature, these axioms are found as "von Neumann axioms"). EUT holds that individuals choose between uncertain prospects by maximising their expected utility, that is, the subjective value or satisfaction of an outcome. To formalize this, let us define a final outcome, o, as a description of the world capturing everything that the agent cares about, and a prospect, X, as a probability distribution over all potential final outcomes.

Formally, EUT takes the following form. Let Ω be the set of all possible final outcomes and $p_X(o)$ the probability of outcome o in prospect X. Then, there exists a real-valued function f such that, for all prospects X and Y, it is true that X is *at least as preferred as* Y if and only if:

$$\sum_{o\in\Omega} f(o)p_X(o) \geq \sum_{o\in\Omega} f(o)p_Y(o).$$

Note: we call the real-function f the utility function, often denoted with u instead of f.

For convenience, most of the time we are actually working with prospects with a finite number of final outcomes with positive probability. With this in mind, we demand that the EUT requires the following four axioms: completeness, transitivity, independence, and continuity. Although a rigorous treatment of all these would extend beyond the scope of this article, we can still try to intuitively make sense of these four terms.

Completeness states that for any two prospects X and Y, a rational agent must prefer X at least as much as Y or prefer Y at least as much as X. Transitivity dictates the acyclicity of preferences, namely, if we prefer X at least as much as Y, and Y at least as much as Z, then we also prefer X as much as Z. Independence has multiple forms, but in the strong version, it requires that mixing, with probability p, two initial prospects with a third one, does not change the order of preferences of the two new prospects. Finally, we summarize continuity by setting that for any two prospects X and Y, with X at least as preferred as Y, by mixing Y, with probability p, with an *extremely good* prospect Z, we can obtain that we prefer the new prospect at least as much as the original X. For those interested, Jeffrey-Bolker and Savage's frameworks of decision theory develop different axioms, using concepts from measure theory and statistics.

If all the "as least as preferred as" motif is too vague, you are right! But we can make sense of all this abstraction by shedding light on the notation. We write

$$X \succeq Y \text{ for "}X \text{ at least as preferred as } Y\text{."}$$

Now this looks *a lot* like a partially ordered set (which is exactly what it is).

If we now return to the beer example, you can state your preferences in the following form:

$$X \succ Y \succ Z \succ X. \tag{1}$$

More specifically, your preferences violate the requirement of rationality known as "three-step acyclicity": if $X \succ Y \succ Z$, then it is not the case that $Z \succ X$. To show that this is indeed a requirement of rationality, we need to show that preferences of the form in Equation 1 are irrational, i.e., they lead to an exploitation via a money-pump.

The standard version of the money pump (see Gustafsson 2013, Tullock 1964) runs as follows. Suppose that you start with X, and an exploiter offers you a trade from X to Z. Since you prefer Z to X, you accept it. Then, you are offered a second trade, this time from Z to Y, which you again accept, since you prefer Y to Z. Finally, you are offered a third trade, from Y to X^-, where X^- is just like X, except that you have less money, and it holds that:

$$X \succ X^- \succ Y.$$

We call this X^- a souring of X, that is, a prospect that is just like X, except certainly worse in a dimension that the agent cares about (for example, think of two identical worlds, except that in one of them we have burned a flower, which the agent cares about).

Naturally, we ask if we can be sure that there always exists such a souring. This follows from Equation 1 by unidimensional continuity of preference (UCP). We assume this requirement of rationality without proof (Hansson 1993).

UCP: If $X \succ Y$, then there exists a prospect X^- such that X^- is a souring of X and $X \succ X^- \succ Y$.

The intuition behind this is that, if you (strictly) prefer X to Y, you do so with some margin, so there should be some amount you're willing to pay to get X rather than Y.

Using sourings, since you prefer X^- to Y, you accept the final third trade, so you end up with X^- (for example, you pay for X: in our case, for the beers you don't get to drink), when you could've kept X for free. This approach of assessing each choice independently from other choices, past or future, is known as myopic choice.

We conclude that a rational agent appealing to myopic choice cannot block the money-pump.

What if we think about our choices in a different way? Consider the so-called naive choice: we now take into account the prospects of all available plans and assess which of these prospects are choice-worthy in a choice between them all, and choose a plan that gets us one of those worthy prospects. This is done without taking into consideration whether we would later depart from that said plan. But does this do the trick?

To see why the naive choice still doesn't avoid the money pump, we introduce (without proof) the following rule, known as the Uncovered Choice Rule (UCR).

UCR: It is rationally allowed to choose a prospect X if and only if there is no feasible prospect Y, such that $Y \succ X$ and, for all feasible prospects Z, it holds that, if $X \succ Z$, then $Y > Z$.

We can also possibly assume that, since $Z \succ X$, the agent also prefers Z to X^-. Then UCR tells us that the worthy prospects, out of X, X^-, Y, and Z, are X, Y, and Z. So, the goal of the agent is to make a plan (and stick to it) such that they end up with one of these three prospects.

Let's now put everything together. Using naive choice and UCR, the agent would still accept the first two trades, since they regard Y as choice-worthy. When faced with the third trade, UCR allows them to choose X^-, because X is not a feasible choice anymore. Thus, the money pump is still working.

Of course, this simple example is not very convincing, and further principles and rules of the game can be developed in order for the agent to avoid this money-pump. However, more complex pumps can be constructed, which can never be avoided (see, for example, the Upfront money-pump, in Gustafsson, 2022). We conclude that acyclicity is a requirement of rationality.

Similar arguments are developed for all the axioms of EUT, and, although not interesting at first, they make use of various mathematical concepts that are worth looking at. In the literature, the concepts are elaborated under the umbrella of decision theory and formal epistemology.

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‘Making an impact in a world of possibilities’

Advertisement

“ASML has so much to offer, there’s always something that fits your profile,” says Swen Sekha. Swen and his colleague Ward Dijkman are two new graduates who recently joined ASML’s management traineeship in Veldhoven. Besides working on technological challenges, Swen and Ward experience first-hand how the company also takes social responsibility and cares for its employees.

Ward obtained his master’s degree in High Tech Engineering, with a specialization in Micro & Nano Science. Swen graduated in Applied Physics, with a specialization in Renewable Energy. Ward: “I wanted to work in the high-tech industry, there was no doubt about that. But I didn’t want to have to choose a single area of specialization right from the start. I heard about traineeships as a way of getting to know companies and discovering what possibilities are available for me. With its management traineeship, ASML offered a terrific opportunity in this context.”

You’ve both been at ASML for a few months now. How have you found it so far?

Ward: “It’s a big company, which can feel a bit overwhelming at first. But you soon settle in. Everyone is willing to help you, and there are lots of tools to support your success in your role. For example, there is a buddy system: someone who answers all your on-boarding questions and who is always there to lend an ear.” Swen: “It has struck me how the ‘three Cs’ – which stand for ‘Challenge’, ‘Collaborate’ and ‘Care’ – are embedded into everyone’s behavior within ASML. You have various mentors to help you out at the technical level. And in terms of ‘Challenge’, just as we learned to do during our studies, we challenge each other to see our work through fresh eyes.”

'Challenge' is indeed very important within ASML. So are you also made responsible for challenging yourself and taking new steps?
Ward: "My first traineeship assignment is related to the supply chain. My buddy tasked me with making sure that the warehouses don't stock too many parts, and I am held to account on that. I was given the necessary responsibility and trust quite quickly, even though you're supposed to have more experience and training for this task. So I feel like a fully-fledged employee rather than a trainee." Swen: "Proactiveness is highly appreciated. During my first assignment I started to look for additional challenges. Now I am part of multiple projects, which shows just how much they reward proactiveness here. People are comfortable with giving you responsibility, and I like getting that responsibility. We have to arrange our next assignments ourselves too."

How do you notice in practice that ASML makes it a point to take social responsibility?
Swen: "One of my projects relates to eliminating plastic bags from one of our plants. We're working on reusable packaging to increase sustainability and reduce costs, which is a sizable challenge for ASML." Ward: "There are various social impact initiatives. For example, every employee is allowed to spend one working day per year volunteering." Swen: "Diversity and inclusion is an important theme within the company. At ASML, people from many different nationalities work together. To make sure we feel at home, there are many communities for different groups. Education efforts ensure that as many employees as possible come into contact with these communities and learn what they stand for, so they can join them when they feel like it." Ward: "Even in my own team of 14 people, we have seven different nationalities. One nice thing about diversity is that some people want to be free at Christmas and others prefer to take time off for Ramadan or Chinese New Year. That's useful in departments that have to be staffed all the time."

Have you already discovered first-hand that you can make a real impact with your projects?
Swen: "Yes, thanks to being given responsibility, you can also make an impact. At ASML, it is not so unusual to be able to make a mark within such a short space of time. Colleagues in the factory have told me they're happy that we're working to reduce the number of plastic bags we use. Moreover, the new solution is more pleasant for those employees to work with. It's very nice to hear feedback like that." Ward: "Not all projects make it easy to see your personal impact, but for my current project, I see my weekly improvements reflected in the data. It feels very good to see that we really are reducing stock levels."

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Perio Interview: Marcos Guimarães

AUTHORS: **D. ROSA, HE. NITA**

Marcos Guimarães is a professor at the RUG, well-known to Physics students from courses such as Quantum Physics 1 and Mesoscopic Physics. He also leads the research group Opto-Spintronics of Quantum Materials. When not busy teaching or investigating the interplay between light, electron charge, and spin in ultra-thin materials, he is invested in bridging the gap between professors and students. Thus, we thought an interview would be the perfect opportunity for our readers to get to know him a little better.

Is there any reason why you chose Groningen for your career? Are you happy with your decision?

Yeah, there are several reasons, including a little bit of luck, in a certain way. I did my PhD here, but I came from Brazil. I did my Bachelor's and my Master's there, then I applied for a PhD abroad, because I wanted to get experience in the specific topic that I like, two-dimensional materials (at the time it was graphene), and I liked spin stuff and magnetism. So I applied to a few groups all over the world and I got a few offers, from which Groningen was one of the best. Then, I came here, did my PhD here, met my wife (at the time my girlfriend). After finishing my PhD, we went to the USA. for a postdoc. We stayed there for 3 years, then I decided that the US was not a place to be long-term, and I think that was a good decision given the stuff happening right now. Afterwards, I got back to the Netherlands (to Eindhoven, actually), with an NWO Veni grant. As soon as I got back to doing my second postdoc, I said okay, I will start applying for professorship positions. Groningen turned out to be the right time and the right place: a position opened exactly in the field I wanted to pursue. It was a good place. I knew it, and I knew how it would be. My wife is from here, so it also helps being close to family. Thus, we decided to come back here. So this is, in a nutshell, how I ended up in Groningen. And in this nice academic environment too, right? This is a good university, good research is being done here, there are nice facilities and such, so it ticked all the boxes. Of course, there are always points of improvement everywhere, but I think that, overall, I'm happy.

What attracted you to your specific domain in physics?

The reason why I liked solid-state physics, and still like it, is that it's a nice playground to explore quantum mechanics. What I mean is that I can make my own samples. Nowadays I don't make them so often, but if you look at quantum tunnelling, or at the quantised states, you can actually make a sample to test whatever idea you have, and see how fermions (e.g. electrons) or bosons (e.g. phonons or Cooper pairs) interact with each other. Think of Bose-Einstein condensates: basically, for a lot of the stuff that you have in quantum mechanics, you can actually fabricate a device that you can hold in your hand and measure. That was always exciting to me, and I think that's also what pushed me to stay in the field.

Figure 5: Marcos Guimarães

What kind of research are you engaged in right now?

My group works with two-dimensional materials, especially van der Waals materials. These are materials which are layered, and can be made atomically-thin, so electrons can only propagate in two dimensions. And specifically, our group works a lot with 2D magnets, 2D semiconductors, and light-matter interactions in these systems, to basically explore how light can manipulate magnetization in low dimensions, or how we can measure or induce current into semiconductors, which are spin polarised. We can achieve this, for example, just by shining light with a certain polarisation. This is, in a nutshell, what the group does.

Is there one thing that you enjoy most (or least, perhaps) about teaching?

There are many things I enjoy about teaching. I think I always learn when I teach, right? Because I have to revisit the topic, and I always have to get new insights. You have to find different ways to explain the concepts. That gives me a lot of enjoyment. Also, I like a lot discussing with students and getting some questions that make me think. Then we get into a discussion, which I always find exciting. The teaching is also a sort of performance, which is also cool to do. What I don't like about teaching, I think, are all the management tasks that go with it, so answering a lot of emails, especially for Quantum 1. At a certain point, I get a few hundred emails a week, which is quite a lot. Each one takes me a minute or less to answer, but it still took quite a long time coordinating all the tutorial groups and doing the exam correction, as well as making sure that everyone has done their job correctly. I think there was a problem every year, that they booked rooms which are too small or didn't fit the tutorial groups, and changed rooms last minute. This part on the management and the coordination I don't like so much. The part that brings me joy is the teaching, the content and interacting with students.

Do you have any particular story from your time as a professor, that you remember in particular?

I think there are many. A lot of the interactions that I remember and I enjoy are usually the 1-on-1 meetings, so, for example, when students book office hours and then we get to discuss and write stuff on the board. And when we get into discussions, and, really, when I see that it clicks, I think that that is quite beautiful. I also like demonstrations in the class a lot, and there is one in particular that I remember. This year it didn't happen because one of the spectrometers failed, but last year, when I was teaching the hydrogen atom, where you have to calculate the energy levels, and calculate the exact transition to get the wavelength out of it. You have a hydrogen lamp and measure the transition lines, and it gets exactly down to 0.1 nm, exactly right with the calculation. I think that's a beautiful moment, and the whole class went "Wow!". That was something that I really liked, especially for the hydrogen atom, because it's very mathematically heavy, and I skip a lot of steps in class because there's just not enough time. You spend the whole lecture deriving and getting to the formula, but what is the bottom line? Well, it is to explain this spectrum, that is why it was developed, and then to see that, after all this math, when you calculate it you get the exact value that you measure, it's fantastic. I find it really cool.

If you could choose to work anywhere in the world, where would you go? Would you choose Groningen or some other place?

I'm not sure. I mean, one thing that I miss a little bit in Groningen is that sometimes I feel a little bit isolated from the rest of the world, especially when you have visitors coming in from all over the world. I miss that a little bit. I'm not sure where else I would choose to go. Perhaps if there was a very good university in a place with very good weather, I would considered it. If it was not too expensive, and it was not in the States, I think Stanford would be a very good place to go. But I wouldn't go there now. I think I would choose somewhere in Europe, but then the problem is that, usually, nice places to live in Europe don't have a very good university scene. Funding, for example, is not fantastic, so I'm not sure where I would go.

If you were to pursue any other field except physics, or a different domain within physics, what would that be?

That's a difficult question. If it was within physics, I'm not sure what I would choose. Cold atoms, is that far enough from my field...? I think I find it interesting. I wouldn't want to do high energy particle physics, I would definitely find it boring. The theory is too difficult to make an impact by yourself too. I like to be in charge of my own experiments, and that's exactly what attracted me to solid state. Then, if I go out of physics, I think biology would be interesting, but more around biophysics. That's just because there's a lot of complexity there and, I think, a different intuition. I almost failed biology in high school, so it's kind of funny, but I liked it afterwards. If you say OK, no lab involved, no nothing, then, I think computer science or electrical engineering would be kind of my go-to, both career-wise and in terms of finding new problems in this kind of fields. I almost switched to computer science when I was doing my bachelor.

Do you prefer teaching or research?
Research. I like teaching, don't get me wrong, but all things considered, I think research brings me that additional excitement of seeing the things that nobody else in the world saw at that point. I think that is so unique that you can't beat that.

"When we get into discussions and really when I see that it clicks, I think that is quite beautiful."

Speaking about research, is there any colleague of yours that you admire?
I'm going to give a very politically correct answer. I think everybody has good points and bad points, right? But if I were to choose a colleague, I would have to say Bart van Wees. He was my supervisor, and I still admire him quite a lot. He is a pioneer in the field of spintronics, in all sorts of different spintronics directions, and he's super smart. I always find it fantastic to have discussions with him. I think I would definitely put him up there.

There is also Maria Loi, I always enjoy my discussions with her. From the younger people, Loredana Protesescu, who is a chemist, so students from physics won't know her. I have quite in-depth discussions with her, on all sorts of career development subjects, research framing and other things. I also see some of the people younger than me, who are really developing to be fantastic researchers, I think I couldn't name them all.

If I have to choose someone from outside Groningen, then I would probably name 2 of my postdoc supervisors at Cornell that were, in terms of both people skills and scientific skills, the best people I've met. There's Jiwoong Park, who is now at UChicago, and Paul McEuen, who was at Cornell, but retired a couple of years ago. Paul's fantastic, in terms of his insights in physics and the whole field of physics, but also as a person. He is a fantastic guy.

What culture shocks did you experience coming here in Groningen (and the Netherlands in general)?
I think Dutch directness. That always comes up, right? And here in Groningen it is definitely stronger than in the south, for example in Eindhoven. It also depends on the person, and how they bring it up. So I think that was an adjustment for me. In Brazil, I would have this difficulty, especially in the first years of my PhD, that we have the tendency to not really say what we mean, but everybody else would understand. You have to read between the lines and really understand what the person means, and that wouldn't work in the Netherlands, it would just go over their heads. Now, maybe I adapted way too much to this, that sometimes I get complaints from people from other cultures that I'm a little bit too direct with my communication, so that's something that I'm trying to balance now. I think that that was the only type of culture shock that I had. Academically, I felt Brazil was a little bit more open, the professors were more approachable than here. Here I felt there's a little bit more hierarchy, and that's something that I try to avoid, because I like to have my door always open for students and be able to interact. So that's something that, I hope, I did not change.

How do you find life here in Groningen, outside of academia?
I like it, but I think it's better as a student. There are more things tailored towards students. In Eindhoven, for example, there was more stuff to do for people around 30 and 40, since there are a lot of them in the workforce over there. Here in Groningen, it's got orders of magnitude better than when I was a PhD student, but I still think that that is something that I miss. But I like the vibe of the city. It's quite lively. There are a lot of bars and restaurants, which is nice, and I like the style of the city centre too. It's a shame that the Zernike Campus is not closer to the city. I miss a bar in the Zernike Campus, something that brings people together after work, for example. There are a few borrels every now and then. I don't know if the FMF has a regular borrel. In Eindhoven there was a borrel from the student association for physics every Thursday. I wouldn't go every Thursday, but every other week, and the professors would attend quite often too. So that's something that I've been trying to push in Groningen for a while. But I also heard from Francken that here (in the Feringa building) the rules have got stricter for organising stuff. But it is something that I think I miss, to have more of a community feeling, bringing people together, especially to have more interaction between professors and students. I find that important.

Do you have any hobbies that you pursue in your free time?
I try to read every night after dinner. I have a little home office, a little library at home. I like to sit down and read. If it is a weekend I have a little whisky, and during the week I usually have tea. I would like to play golf more often because I used to, but last year I didn't play much. And in the summer, I try to sail a little bit on the lakes close by. I still play quite a bit of video games, too. I have a switch and a PS4. I was wondering if I should get

the PS5, but I realised that if I buy it, my overall time for other things probably goes down. I still try to hold on to see if I have the time to play.

Is there a book that you have read recently, or even longer ago, that you would recommend?

I read one last year, it's very solid-state oriented, but I find it fantastic. It's called *Crystal Fire* and it's about the invention of the transistor. The book starts from the early developments of quantum physics and how that slowly developed into solid state physics, with all the discoveries. Then it gets to the invention of the transistor, after which it also covers some of the politics involved, like the whole thing with the Bell Labs. I found that book quite interesting and it was written in a way that is not too heavy on the physics. I sometimes don't want to read physics books at night, I usually like to read more relaxing things. There is some stuff about the physics, which is nice and makes you think, but there is a lot of the historical perspective. So I would definitely recommend it for anyone who considers solid state physics or quantum or something like that. That was a book that I liked from last year. Currently I'm reading Paul Dirac's biography, which is also interesting, but I am not even halfway yet. I read a lot of Agatha Christie and Sherlock Holmes, those kinds of stories. And there's also the *Foundation* series from Asimov. I've read a few books from the series last year, and I'm now at the last one, that is on my to-read pile. I think, if I were to recommend something, it would be the *Foundation* series from Asimov and *Crystal Fire*.

Do you manage to balance your work with your personal life or do you find that challenging? Is that easy to do here?

No, that would be the short answer, it is not easy to do. I try to have breathing periods, because I know that the second semester is quite heavy, it's hard during the first semester of the academic year because I'm teaching two courses and there are many grant proposal deadlines in October and November. And then all sorts of research things, people trying to finish stuff before the end of the year. I think that is a crazy, crazy period so it's very easy to get lost in work. I try to make sure that I have some breathing time in the period that is to come now, i.e. January to July. I try to work consistently, but having time for myself as well. For example, every weekend I try to take at least one full day off, no work at all. Often times, in the second semester or first semester of the academic year, that does not happen. But every day I cook with my wife, I play with my cat and I read. Usually, if I have to work after dinner, then I work for 2-3 hours, and then I take another half an hour to read, to slow down before going to sleep. That is something I do every day, it's non-negotiable.

How was your Christmas, did you enjoy it?

It was good, with my wife's family and my family. My mum came from Brazil, while my sister came from Paris with her son and husband. We have an older neighbour nearby too that came to celebrate Christmas. So I had a little Christmas in our house, which was fun. I had to do only a little bit of work. So it was not too bad, it was nice. I mostly stayed at home, went to Christmas markets, and also walked around in a few places, I don't know if you know the Drentsche Aa. It's a nice place to go hiking, as much as you can "hike" in the Netherlands. I live in Roden, so there are a few forests close by where I really enjoy walking.

What did you have for breakfast today?

What I have every day, bread, cheese and egg with a latte. That's what I have every day, except Sundays.

What is your opinion about Dutch food, or about the food from other cultures that you can find in the Netherlands?

That's a difficult take. I enjoy pub food in the Netherlands, so the fried snacks like bitterballen, but yesterday, for example, I had stamppot for dinner. Sometimes I enjoy stamppot, not every day, maybe not even every week. I like it, but it is by far not the best cuisine in the world. I think nearly all Dutch people would agree.

Also, I do not cook Brazilian food at home. And it depends on where you are in the Netherlands, in Groningen I've been to a Japanese restaurant that I really enjoyed, Hana Satto in Zuiderdiep, and also Korean fried chicken at Konbu Jiro on Oosterstraat. It had Korean barbecue too, which was also nice. So there are a few Asian food places that I enjoy. And if it is a little bit more sophisticated, like French cuisine, then there are a few nice restaurants that I can find here too, that I also enjoy.

In an apocalyptic scenario, such as a nuclear winter, zombie apocalypse or something similar, which professor(s) would you take with you in order to survive?

I think I would choose Antonija Grubišić-Čabo, I think she would be a good zombie-killing buddy for an apocalyptic scenario. Maybe Andrea Giuntoli as well, because he's a very good karate fighter. If I could take both of them in my team, then I think I would be safe.

Your text could be here!

Are you a student or staff member and do you have an interesting or fun contribution to the Perio*diek*?

Get in contact!

at perio@fmf.nl

Also for questions.

Émilie du Châtelet: Beyond the Translation

AUTHOR: **M. MANDEVILLE**

Émilie du Châtelet (1709–1749) famously translated Newton's *Philosophiae naturalis principia mathematica*. More than that, she greatly participated in the scientific world of the 18th century, joining debates and competitions. First woman to be published by the *Académie des sciences*, she thrived to make science more accessible. To this end, she published many texts regrouping different theories in one place, like the *Institutions de Physique*.

She battled with accusations of plagiarism, but was always supported by Voltaire, Maupertuis and Clairaut, among others.

To this day, she remains one of the most influential scientific women in France, and her impact can still be felt now. However, most people remember her as Voltaire's lover, and not necessarily as a mathematician. In this essay, we look at her life and two of her most popular works, and conclude on her impact on science education in France.

Introcution

"This translation that the most erudite Men of France should have done, and that the others should study, was undertaken and finished by a woman at the surprise and glory of her country."

This is Voltaire's opening sentence of the historical preface to the French translation of Newton's *Philosophiae naturalis principia mathematica*, and it encapsulates very well the work done by Émilie du Châtelet.

Du Châtelet is remembered today for this famous translation, which to this day remains the only French one.

Curious about mathematics and languages from an early age, she devoted most of her life to regrouping scientific knowledge. She aimed to put contradicting theories on the same page, giving the reader all the tools to form their own opinion. Her two biggest works were published with this in mind. Émilie was one of the first to write a full compilation of the theories in physics in that time, and she greatly participated in the development of Newton's theories in France.

Figure 6: Émilie du Châtelet

She worked with Voltaire for a large part of her life, having a front seat view to his experiments and discoveries. When she disagreed with him, she would secretly do her own experiments, which lead to the two of them participating at the same contest in 1737.

As Voltaire's lover, she is mentioned in many of his poems and texts, and he always describes her under a good light. However, not everyone who talked about Émilie was as positive as Voltaire was. For instance, in a letter from the Marquise of Deffand, we can read:

"Picture a tall and dry woman, [...] a pointed noise, [...] big arms, big legs, [...] without any talent, she became a geometer to appear above other women. [...] It is thanks to M. Voltaire that she will be immortal."

Clearly, being a mathematician and a woman in in the 18th century was not easy, and this is further illustrated by the fact that Émilie du Châtelet is one of the few female scientists still remembered. Many saw her success as only part of Voltaire's, who is still to this day more famous than her. Émilie defended the feminist cause, arguing that many women were not aware of their talents, either by their education or by prejudice. She thanks chance for allowing her to meet people who believed in her (Hagengruber et al., 2020).

During her life and career as a mathematician, du Châtelet had to fight to be taken seriously, and to not get her work stolen. Indeed, Samuel Koenig tried to take credit for the *Institutions*, arguing that Émilie had taken his ideas (Racine, 2009). Maupertuis and Clairaut, took her defense, but this did not close the debate. Furthermore, some try to argue the extent of Clairaut's role in the translation of *Principia*, how much did he write, how much did *she* write?

Émilie was an active participant in scientific life – attending cafés and debates. She placed herself above disputes, taking the place of mediator, of witness. She often frequented the café Gradot in Paris, a place where new ideas were exchanged and political news were discussed. Many scientists and philosophers met up, including Maupertuis and Clairaut. However, such places were forbidden for women. This didn't stop the marquise, who simply dressed as a man.

As Doridot (2006) says, Émilie was perhaps the only woman who, in France, incarnates the heart, eye, and curiosity of the 18th century.

In this essay, we first look in detail at Émilie's life, and particularly at her scientific career. We then delve into her two biggest works: the Institutions of Physics and the translation of Newton's *Principia*, and how she went beyond a faithful transcription. Finally we conclude with the impact that Émilie du Châtelet had on scientific writing and scientific life, and how she helped shape the standard for textbooks.

Émilie's life

Gabrielle Émilie Le Tonnelier de Breteuil was born December 7th 1706, in Paris. Similarly to her brothers, she was taught mathematics, foreign languages, horse riding, gymnastics, dancing, etc. At twelve, she could already speak Latin, Greek, German, Spanish, English and Italian (Racine, 2009). By the age of 15, Émilie knew everything about Locke, Descartes and Leibniz. Her main interest was in understanding the universe and its laws, but she also found joy in diamonds, makeup and clothing (Doridot, 2026).

In 1725 she married Florent Claude, marquis du Châtelet, acquiring a higher rank in society. They had three children together, he supported her studies and let her live her life freely. In 1732, she moved to Paris and started to follow mathematics lessons with Moreau de Maupertuis; a mathematician, astronomer, physicist, and member of the *Académie des sciences*. They began a short affair, after which Maupertuis decided to let his friend Alexis Claude Clairaut continue Émilie's education. Clairaut was a renowned mathematician and physicist who contributed to the laws between gravity and the shape of the Earth. He worked with Émilie until her death.

In 1733, Émilie met Voltaire and they became quickly inseparable, visiting the Opera and the theatre and working together on physical and metaphysical problems. In 1735 they moved to the castle of Cirey, away from Paris, which turned into a place of scientific experiments. When the *Académie des sciences* launched in 1737 a contest on the nature of fire and its propagation, Voltaire experimented with the weight of molten iron. When measuring the iron after cooling, he realised that the weight was always the same. After proceeding the experiments again with cast iron, he concluded that the weight was greater when cooled than when heated. Voltaire then theorised on the nature of fire, in particular that it was an element in itself, that no other substance could become fire. Du Châtelet, present at every experiment, was not convinced by this conclusion.

She signed up to the competition, unbeknownst to Voltaire, and wrote during the night an essay of 139 pages, aiming to summarise all the knowledge on the topic, without introducing any new experimentations or theories. The academy gave the price to Leonhard Euler, but both texts by Voltaire (1738) and du Châtelet (1744) were published. This is the first time that a text written by a woman was published by the *Académie des sciences*.

Du Châtelet wrote the *Institutions de Physique* in 1738, in order to gather in a single book the more recent discoveries about the development of physics. She dedicated the book to her son, so he wouldn't have to search everywhere for new theories, like she had to when she was his age. We will elaborate more on this work in the next section.

Then, in 1745, she began the biggest project of her life: translating Newton's *Principia Mathematica*. The translation was quickly done, but she also added her own comments, and worked on it until her death, having dropped off her manuscript at the Royal Library merely days before. Émilie died September 10th, 1749, six days after giving birth, from a post-partum infection.

Institutions de physique

Émilie du Châtelet dedicated the Institutions of Physics, written in 1738, to her eldest son, then eleven. She writes directly to him in the preface, "You are, my dear son, in this happy age when the mind begins to think, and when the heart has passions not yet lively enough to disturb it."

As a child, she had studied mathematics and physics by reading books from her father's library, and by taking lessons from some of the most famous mathematicians of that time. However, she wanted her son, to be able to learn from one book, "In this work, I will try to place this science within your reach [...] and I will try to give to it here that which suits your age."

She writes about the development of science, putting the discoveries back in their context, and providing examples of the problems they solve. Her goal was to write a complete book, listing all scientific knowledge of that time: "[...] although we have several excellent books of physics in French, we have no complete book of physics, except the short treatise of Rohault, [...] and a man who had studied physics only in this book, would still have many things to learn."

She explains that science evolves, that one may have a clear idea of certain principles, but those principles may be ill-defined, and the next scientists will bring more precisions. In her book, she brings together different ideas, comparing them and describing counter-examples, leading to an evolution of definitions. She takes the example of Leibniz, arguing against Descartes on the most rapid movement of a wheel, explaining that one can show that the most rapid movement cannot be measured, as those movements may increase to infinity (du Châtelet, 1740, Ch.I, §5).

Marie-Noëlle Racine (2009)describes the way Émilie writes her book by looking at Chapter 18. The chapter begins with definitions and geometric proofs of the properties of a pendulum (§443–§456). A pendulum is defined as a "heavy body, suspended by a thread, and attached to a fixed point around which it can move by the action of gravity, once it has been set in motion."

She then places pendulums back into their historical context: "Galileo was the first to envision suspending a heavy body by a thread [...]. Thus, we can regard him as the inventor of the Pendulum, but it was Mr. Huyghens who first used them in the construction of Clocks." She also explains what problem the clocks solve; measuring time correctly. However, certain conditions like cold, heat, or dust could lead to some inaccuracies in the clock (du Châtelet, 1740, §458). She then explains Huygens' reasoning: "Mr. Huyghens had foreseen these inconveniences and [...] thought of making the Pendulum [...] oscillate along arcs of a cycloid instead of describing arcs of a circle," since in a cycloid, all arcs are traversed in the same time.

This allows du Châtelet to introduce the notion of cycloids, generated by a circle that rolls without slipping along a straight line (Figure 7).

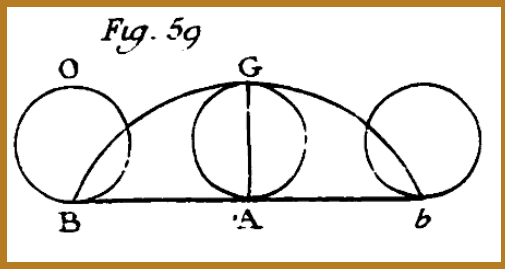

Figure 7: Sketch of a cycloid (du Châtelet, 1740)

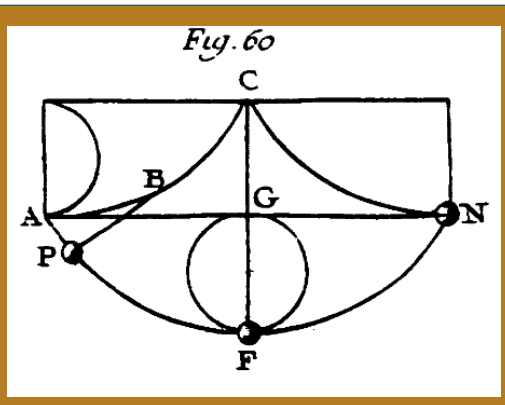

Figure 8: Sketch of a pendulum oscillating along a cycloid (du Châtelet, 1740)

An example (Figure 8) is given right after the mathematical definition, and figures are used throughout her book, to illustrate her words. She makes a choice in the notions she introduces: for instance, she doesn't mention the area of a cycloid. She argues that the

calculation of the area is not needed in her explanations, and therefore decides to not mention, as to not confuse the reader with too much information.

About this, she writes: "I will therefore content myself with indicating to you here those properties that are necessary to the subject that I am treating."She also provides a book that offers more details on the topic, for the reader that might interested in knowing more: "[...] in the excellent book of Mr. Huyghens, De Horologio Oscillatorio, or in the treatise that Mr. Wallis gave on the Cycloid."This highlights how she viewed the purpose of her book: a textbook, a reference, regrouping knowledge and providing ways for the reader to learn more if they wish so.

This is not the only book that du Châtelet wrote with the aim of regrouping scientific works to educate the reader. Seven years later, she embarked on the biggest project of her life; the translation of Newton's *Philosophiae naturalis principia mathematica*.

Principes mathématiques de la philosophie naturelle

Du Châtelet's translation was published as two volumes in 1759, a decade after her death. To this day this is still the only French transcription of Newton's work. A translation into French was needed at the time, as it was the language of scientists, and certain more recent concepts could not be properly explained in Latin. As Voltaire comments in the historical preface, "French, which is the common language in Europe, and which has gotten richer with new and necessary expressions, is better suited than Latin to spread all this new knowledge."

Du Châtelet began to study Newton's works in 1736, together with Voltaire. She corrected parts of the second edition of *Il Newtonianismo per le dame* by Algarotti (1738), which aimed at explaining Newton's *Principia* to women, and began her translation in 1745. More than a faithful transcription, her curiosity and her ambition of making science accessible led her to add her own comments.

Du Châtelet's comments and additions make up about 100 pages and are found in the second part of the book, after the translation. In the first chapter of that part, she redefines the concepts of time, space and movements, and she distinguishes between *absolute* and *relative*, a difference that is not emphasised originally. She adds in the footnotes what an ellipse is by taking the example of the oval shape drawn by gardeners (du Châtelet, 1759, p.13). She gives numericals examples of Kepler's laws, and defines multiple terms, like area, periodic time, tangent and convexity (p.15). As Hermann (2008) says, this section is aimed at educated readers, but not necessarily mathematicians or physicists. She provides illustrative examples to some of the more abstract concepts.

Émilie places definitions and theorems in their historical context, gives the rules to follow in the study of physics, and the different observations that can be made. She states Kepler's empirical laws, his and Hooke's intuitions, as well as what Newton brought to the theories and the results that follow.

The historical context begins from the introduction of the second volume. She briefly mentions how astronomical models evolved through the centuries, going back to before Pythagoras and the Babylonians, mentioning Aristotle and Ptolemy (du Châtelet, 1759, Ch.1 §III–§V), while Newton only mentions Kepler. She limits herself to an abridged description of the phenomena happening in our solar system. Instead of detailing precisely how astronomers thought centuries earlier, she restricts her explanation to more recent scientific knowledge, citing results published merely two years before her death. She includes references and quotes from some of Newton's other works, which he did not.

In the first chapter, Émilie adds, for every property of a planet, a description of experiments showing these properties. For instance, when talking about the opaqueness of planets, she explains how this was discovered: "When these planets pass between us and the Sun, they appear on this star as little black dots." She also suggests that the Sun is a "body of fire" (p.13) and presents a summary of knowledge from that time, either obtained by observations or measurements, on planets and their satellites (du Châtelet, 1759, Ch.1 §X–§XX).

Through her book, the reader can thus follow a true astronomy lesson, starting with the historical context and old theories, and ending with the current ones. Important notions are explained through definitions and theorems, all in words as mathematical notation had not been introduced yet. Everyday examples help the reader visualise, and astronomical observations and proofs help convince them. As Hermann (2008) says, such a method of writing is still used today in France for high-school textbooks. We begin with the statement, then the proof. A hypothesis will be corroborated or contradicted via experiments or observations. The only difference is that, today, we have computers at our disposal, allowing us to solve problems numerically, when the analytical solution is not possible.

Conclusion and discussion

"There has never been a more erudite woman than her." Another quote written by Voltaire in the preface to the *Principa*, talking about Émilie du Châtelet. The preface is full of quotes like this, showcasing the love and admiration that Voltaire held for her. Moreover, this shows the support he gave her – by writing the preface and by giving such praise, the reader is more inclined to see Émilie positively.

As seen in this essay, Émilie wished to regroup scientific knowledge and to give the reader the full story. She also wished to provide references, in case the reader was curious, and to give examples to illustrate her words. She did not prove any theorems, or discover any new principles. Instead she dedicated her life to making science accessible, and in particular the works she believed to be of great importance.

Her way of writing texts survived her – textbooks used in middle and high school use the same principles and methods. First, we give a statement or hypothesis, which we then prove. Examples or experiments, either before or after, help provide insight. Finally, the conclusion provides an opening, either onto applications or with references for a deeper understanding.

The content of du Châtelet's books is still used today, albeit with more modern examples. Her definitions and propositions have been modernised into contemporary French, and mathematical notation has been introduced, but students still study the fully written out texts. Namely, I was taught about Newton's laws through Émilie's worded definitions.

However, despite the concepts still being studied in school, Émilie du Châtelet is not mentioned much. In fact, I only discovered her when I decided to, out of curiosity, borrow the French version of *Principa Mathematica* from my local library. It is only then, reading the translation and later her commentary, that I realised the impact she had on my learning of physics.

The only mentions of Émilie du Châtelet that I remember from class were with regards to Voltaire's poems – she was considered as nothing more than a lover. It is a shame that such an important woman of the 18th century is only remembered through her relation to a man – however influent he might have been. Her texts have all heavily contributed to the advancement, propagation and accessibility of science.

So, to conclude this essay, I think the role of women in science should be highlighted more. If Émilie du Châtelet – a pillar of the Age of Enlightenment – is barely remembered in the public eye for her contribution to mathematics and physics, how many more influential and impactful women have been forgotten? Finally, putting forward the role that such woman had on their time, and on mathematics in general, could be beneficial for all the young girls and women who might be considering a career in mathematics. After all, is it not inspiring to see someone like you achieve great things?

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KBE'25
Hamburg, Copenhagen, and Lund

AUTHOR: **R. RODENBURG**

It has been more than a year since FMF went on KBE, our annual academic excursion that takes students to various destinations in Europe.

The trip allows students to learn about interesting research groups doing novel work, ask PhD students about work-life balance at their institutions, and fall in love with the food served in the canteens, which is invariably better and cheaper than Beijk.

This year, our excursion took us to Hamburg, Copenhagen, and Lund, all of which are home to prestigious experiments and institutes. In Hamburg, we visited the European XFEL, a 3.4-kilometre linear electron accelerator used to generate incredibly short and bright X-ray pulses, which are used to better understand the molecular composition of biological materials, for example.

In Copenhagen, we visited the Niels Bohr Institute, which is still active in research. The visit also included a tour of Bohr's office by the institute's archivist, which was the highlight of the trip for me. Through his work on the archive, he was able to very clearly sketch a picture of the kind of person Niels Bohr was.

In Lund, located in the south of Sweden, we visited the research group of Anne L'Huillier, whose work on ultra-short laser pulses was jointly awarded the physics Nobel prize in 2023. These ultra-short pulses are short enough to generate pictures of an electron as it orbits the nucleus, allowing for new insights into atomic dynamics. Although she was travelling at that time, we were given a wonderful tour of the experiment.

There was, of course, a lot of preparation that went into organising the excursion. The committee responsible consisted of Stefi, Andra, and me. We booked all the talks, visits, hostels, and transport for the trip and put together the schedule, which gave everyone just the right amount of sleep deprivation. We were also responsible for guiding the participants throughout the entire trip. Naturally, this meant that we had to be easily visible at all times, which we achieved with our beautiful, bright orange committee clothing, which you can judge for yourself.

Our trip started well: we were picked up by the FC Groningen team bus, which brought us to Hamburg. I like to think that our presence blessed the team, because they are now fifth in the competition this year after coming back from relegation last season. For me personally, this meant that the most nerve-wracking part of the trip was already over, as I had been very worried that the bus would not show up due to some miscommunication with the bus company on my part.

Besides the academic programme, we also had some cultural activities planned. In Hamburg, the highlight was our visit to the miniature museum, which turned out to be a perfect fit for the FMF demographic. We then travelled onwards to Copenhagen by train, and after arriving, we immediately had to take the tram to attend an institute talk. After taking a Deutsche Bahn train, and us simply improvising every public transport transfer in Copenhagen, we arrived exactly on time, right on the minute, miraculously. The talk on Arctic ice core drilling expeditions was definitely worth it though.

One of my favourite moments of the trip was returning to the hostel after an evening walk to see one of the participants on stage performing in a jazz band which was visiting the bar associated with the hostel. They whipped us all onto the dance floor.

On the second-to-last day, we had our day-trip to Lund, and we had to catch the Flixbus at 7 AM to arrive on time before the first talk. Considering that the excursion was almost over, everyone's energy levels were rather low that morning, mine as well, mostly due to my enthusiastic patronage of the hostel bar. Whilst waiting on the (delayed) Flixbus, I and probably many other participants were regretting my idea to include a day trip to Lund. However, when we did finally arrive in Lund, after some small struggles at the border with the immigration police, we had a wonderful time! After the academic part of the day finished, we had plenty of time to enjoy the Lund old town and have a nice group dinner together with an FMF alumnus.

Then, the final day of the trip had already arrived, and we had to return to Groningen after a wonderful adventure.


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‘Establishing an Audio Catalogue of Underwater Sounds’

Advertisement

At Witteveen+Bos, we were selected to participate in an exciting project commissioned by the European Commission, collaborating with international partners from Spain, Italy, France, Denmark, and Sweden. Our goal was to develop an audio catalogue of underwater sounds, named ECoSS (European Catalogue of Sound Signatures). This extensive library aims to compile sound recordings from European shallow seas, including the Wadden Sea and the North Sea near France.

Creation of the Audio Catalogue

The project began with the collection of raw audio data from various underwater environments. This data underwent thorough processing to extract usable sound recordings. Utilizing these large datasets, we created a robust catalogue—a comprehensive library of recordings from shallow seas.

Sound fragments were categorized based on their source. While our primary focus was on anthropogenic sounds such as fishing activities, shipping, and wind farm construction, the catalogue also includes biological sounds (dolphins, whales) and natural sounds (waves, precipitation, earthquakes). These fragments trained an AI algorithm through Deep Learning, enabling efficient categorization of new sound fragments. Thus, we effectively established a “Shazam” for underwater sounds.

International gatherings

In late 2024, we had the privilege of traveling to Brussels for the launch of the 'ECoSS library of underwater sounds'—the European Catalogue of Sound Signatures. This event showcased the remarkable outcomes of international collaboration. Furthermore, we submitted an abstract to the One Ocean conference in Nice and were accepted to present orally at this prestigious event.

Integration of Mathematics and Data Science

In this project, I utilized my mathematical background in an innovative way to analyze audio files, manage large datasets, and apply AI techniques. Mathematics and data science were essential to the development of the ECoSS catalogue. Following the FAIR principles (Findable, Accessible, Interoperable, and Reusable), we ensured that our data was properly cleaned and organized. This allowed us to implement complex algorithms for sound categorization. The use of AI and machine learning models enabled us to efficiently classify and identify underwater sounds, showcasing the powerful synergy between technology and environmental science. If you have any questions or would like to learn more about our work, please feel free to reach out. You can contact me at martijn.ter.steege@witteveenbos.com.

Game Review
Poetry for Neanderthals

AUTHOR: **Q. HUANG**

Have you ever felt the primal urge to communicate in grunts and bonk a head or two? Or do you yearn to be a Stone Age bard and describe what a humpback whale is to your shepherd companions? Then consider giving 'Poetry for Neanderthals' a try at your next boardgame evening!

Some time ago, Perio went for a cozy boardgame evening. Under RoMo's expert suggestions, the editors at Perio dusted their pantry, and pulled out this classic game.

Game Rules

The premise of the game is rather simple. It is, in essence, the same as *Pictorial*, but you describe everything with single-syllable words. The exact rule is as follows: everyone competes into teams, and at each turn, one out of each team is given a card with an item for the others to guess. Of course, the person, also referred to as the *poet*, must communicate in one-syllable words and must not use any word on their card. You win by gaining points through correct guesses.

Figure 9: Game rules

Scoring system

At each turn, you get 90 seconds with the goal of getting as many cards as possible. On each card, there are two words. The first word is simpler, and the second word builds on top of the first word. So, the more specific the word, the more points the pair can get by guessing correctly. Typically, it's easy to guess the second word given the first one. For example, a card might say "shoe" and "shoelace," then you score one point if your team gets "shoe" and another two points if you get "shoelace" too. If the poet violate the rules, they lose one point and everyone else gets to hit their head with an air-filled club.

Review

The game has a hilarious dynamic, where you might find yourself tongue-tied, stumbling over your words, and the evening might just turn into a good ol' show of mimes. In the beginning, Annisa and I were struggling big time, as we couldn't find more than two words of one syllable every minute. And, when I do find a good word, it turned out to have more syllables than when I said it in my head. This meant that we burned through the cards very quickly because we couldn't describe or guess it. However, after a few rounds, we found that RoMo was still suspiciously eloquent despite only speaking in one syllable at a time. So, I decided to observe him.

As it turns out, the way we speak on a day-to-day is one sound at a time. So, the best way to win at this game is to just go with the flow and try not to think too much. At the end of the day, the worst that could go wrong is a bonk from a club - and most of the time, no one knows if you spoke a syllable more (lest you use "syllable"). Say, if you think about it, is "fire" made of one or two sounds?

This game gets you to better know people and the way they think. At times, I had to the card after they couldn't get it after a solid minute. They'd shout "how was that a woolly mammoth?" when I was trying to make a reference to the *Ice Age* franchise. After rounds, we would have sarcastic but heartfelt conversations about each other's existential crises and childhood. The game serves as a good conversation starter within a group.

In the end, I find this game quite enjoyable because of its simplicity and the chaos it brings. It is different from what I do in my daily life. So, it is nice to relax the perfectionist, critical-thinking muscles and do some speech exercises with some friends.

Art Section

My Journey with Photography

Author: A Hirsh

In 2023, after moving to Groningen, I started getting inspired more and more by capturing what was right in front of me. The streets of Groningen, the nature of Groningen and the people of Groningen. Now, don't get me wrong, I had and still have absolutely no clue what I am doing, but after joining Fotocie, I thought that maybe I could just mess around, go outside, and take pictures of the things that I liked. A couple of months later, I discovered my dad's old camera, and after going through the childhood pictures still saved on it, he entrusted it to me. So now, every now and again, I go outside and see what I can capture.

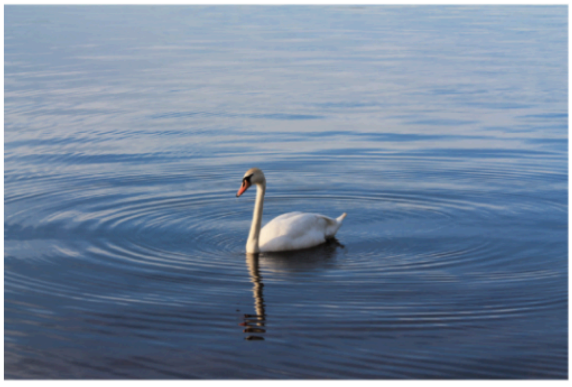
Clouds

I have always been obsessed with clouds. The way they move, the way they can look like they are taken straight from a painting, the way they shine brightest when the sun is at its lowest.

At some point, I started a study of clouds through my camera. I began actively searching for different textures, colours, and constellations of clouds. I noticed that the clouds move a lot faster in the Netherlands than in my home town, and I take comfort in that thought a lot.

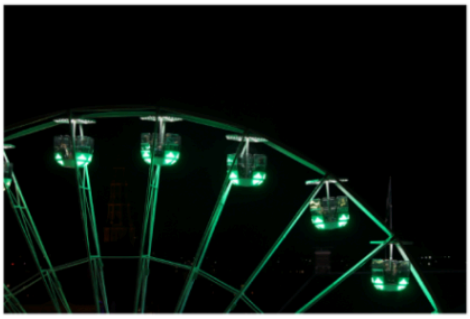
Anything can be inspiring

Apart from clouds, I of course found myself taking pictures of all kinds of motives. Since I was just in it for myself, I was trying out everything. I often used my camera as an excuse to get out of the house, to have a bit of a purpose, so I often took pictures of nature and the surroundings of my home.



City lights of Groningen

After dabbling in photography for a couple of months, I also started following some local photographers from Groningen. Two of them, Harmen van der Vaart and Daniel de Jong, were offering some "Fototours." These were workshops where, together in a small group, you would walk around Groningen, take pictures together and be able to ask them for any sort of tips and tricks. Needless to say, I joined one of their fototours, centered around the city lights of Groningen. I must say, I felt completely out of place, as the only student, the only international, trying my best to understand the Dutch announcements, and a complete amateur. Still, everyone was extremely inviting and helpful, and I did get some very nice pictures and a lot of advice out of it.



Travels

I also took the opportunity to take pictures when I was abroad or on smaller trips.

Conclusion

In conclusion, I hope that I was able to inspire you a little bit by showing you my pictures. You never have to be an expert at something to try it, and you will get better over time. Even if you're not going to start photography now, I hope that I have shown you that stepping out of your comfort zone and trying something new is never a bad idea, and might actually get you somewhere. I know that not that many people have a camera that they can just use for things like this, but you can always start with your phone, that is what I did! I hope to pick up photography a bit more again soon. Life has made me quite busy recently, but I still really want to teach myself how to edit properly. All the pictures you saw are completely raw.

Art Section: Poetry

Infernal Solitude

AUTHOR: **A. SCHMITT**

Infernal solitude, you ethereal beast!
You're hidden deep inside,
and strike when expected the least.

Your fangs are sharp,
they pierce deep through the bone,
yet I can see no wounds
I'm just lost, alone.

I can see it in your face -
that wicked smile of yours.
'He knows what's happening', you say,
'He knows he's drowning in remorse'.
'He knows what he has to face'
Alone.

And so you watch with amusement
that poor soul you have forsaken
for a suffering so fervent
it can't be mistaken
with any pain one can imagine.
Be it as horrific as a blade
cutting deep in your skin.

For it is what we don't see
that scares us and hunts us the most.
And it just so happens that today
solitude has become your host.

I usually write poems when I feel strong negative emotions. This piece reflects a time in my life when I felt left out, neglected. Though, for me it ties to a very specific personal situation, I think you could perhaps find it relatable. All of us feel down from time to time, with loneliness being a potent candidate for one's negative emotion of the day. I hope you enjoy this glimpse of my artistic endeavours and find something enriching in the poem, if nothing than perhaps the fact that it's "okay not to feel okay" and you're never alone in feeling bad, as unbelievable as it may seem in the moment.

Recipe
Migas

AUTHOR: **M. PONCE ALCAIDE**

If you have visited any part of Spain, chances are that you have stumbled upon migas. This rather simplistic looking dish entails more secrets than one could think at first sight. Spanish mothers have been cooking it for centuries, and it is one of the most customizable dishes in the whole Spanish kitchen, requiring only bread, meat and oil as essential components. You can eat it hot, cold (why would you do this?) with vegetables, without them, with meat, without it... The recipe I'll show you is the one that has been done in my family for generations, it may be one of the infinite variations, but it is one of the best, trust me.

Recipe

Preparation time: ~ 45 minutes
Allergen information: This recipe mentions gluten bread.

Main Ingredients

- Half a stick of chorizo
- Half a baguette of bread (any bread, even hard one, is valid for this recipe)
- Olive oil
- Half a package of cut bacon
- Half a green pepper
- Half a red pepper
- Two or three garlic cloves
- As much salt as you deem appropriate.

Cooking Instructions

1. Cut the bread with a bread knife into small slices. Then separate the slices into small crumbs of bread and put it aside for later.
2. Cut the chorizo into medium slices (no larger than half your thumb), cut the peppers into thin wedges and cut the garlic into cubes.
3. Fry the chorizo at high heat with a bit of olive oil until it is well done in the frying pan. Pull it out in a separate container leaving the oil and grease behind.
4. Without cleaning the pan, cook the peppers until they are toasted and pull them out to the same container as the chorizo (leave the oil behind again).
5. Cook now the bacon and the garlic until they are well done. Do not pull them out, now the fun part begins!
6. Add all the chorizo and pepper to the pan and turn it to low-medium heat. Season to liking with salt and black pepper (it should not be required due to the chorizo)
7. Finally, add a bit more of cooking oil and the breadcrumbs. Stir until the mixture looks brown and toasty. Enjoy your Spanish migas!

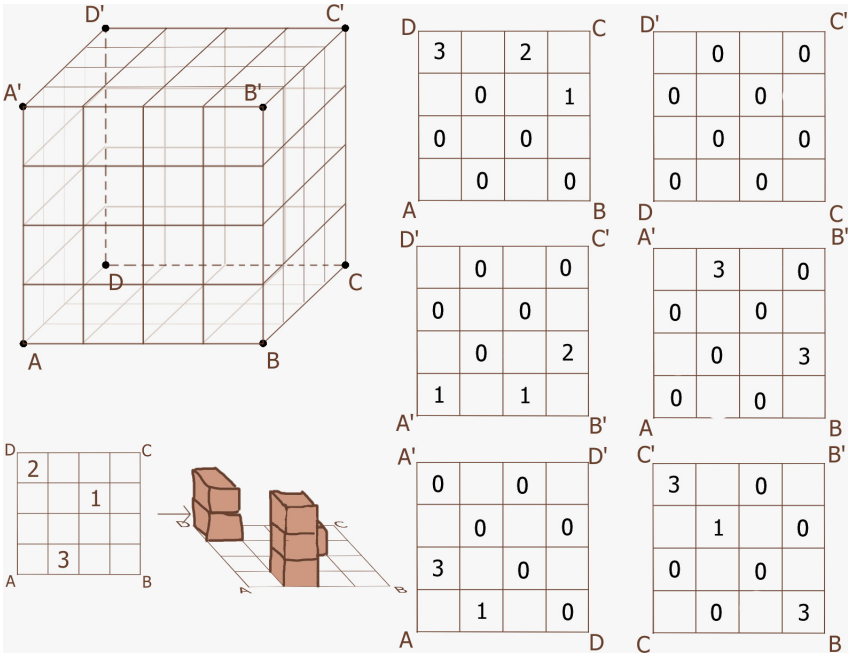
Brainwork
Cubework

AUTHOR: **HE. NITA**

Below is an opaque cube-shaped box with sides of length 4. The inside is filled with smaller, weighted cubes with sidelength 1. They are stacked on top of each other and stuck in place. Some tiles on the outside of the bigger box display a number corresponding to the amount of stacked boxes connected to it in a straight line, as shown in the example.

The exercise left to the reader is to fill in the other squares to find out the arrangement of the cubes inside and reconstruct it, as no one cube affects less than two tiles!
For example, if the leftmost, topmost and furthest slot is filled, the numbers on the connected tiles is at least one. Similarly, if any tile would read "4", its opposite can only read "4" as well!

Since the box is not fully filled, some tiles will read "0", despite the space next to them being fillable with no repercussions. The proper solution, then, has the most "0" tiles possible.
This will not be on the exam, so only stress about it for bonus points.

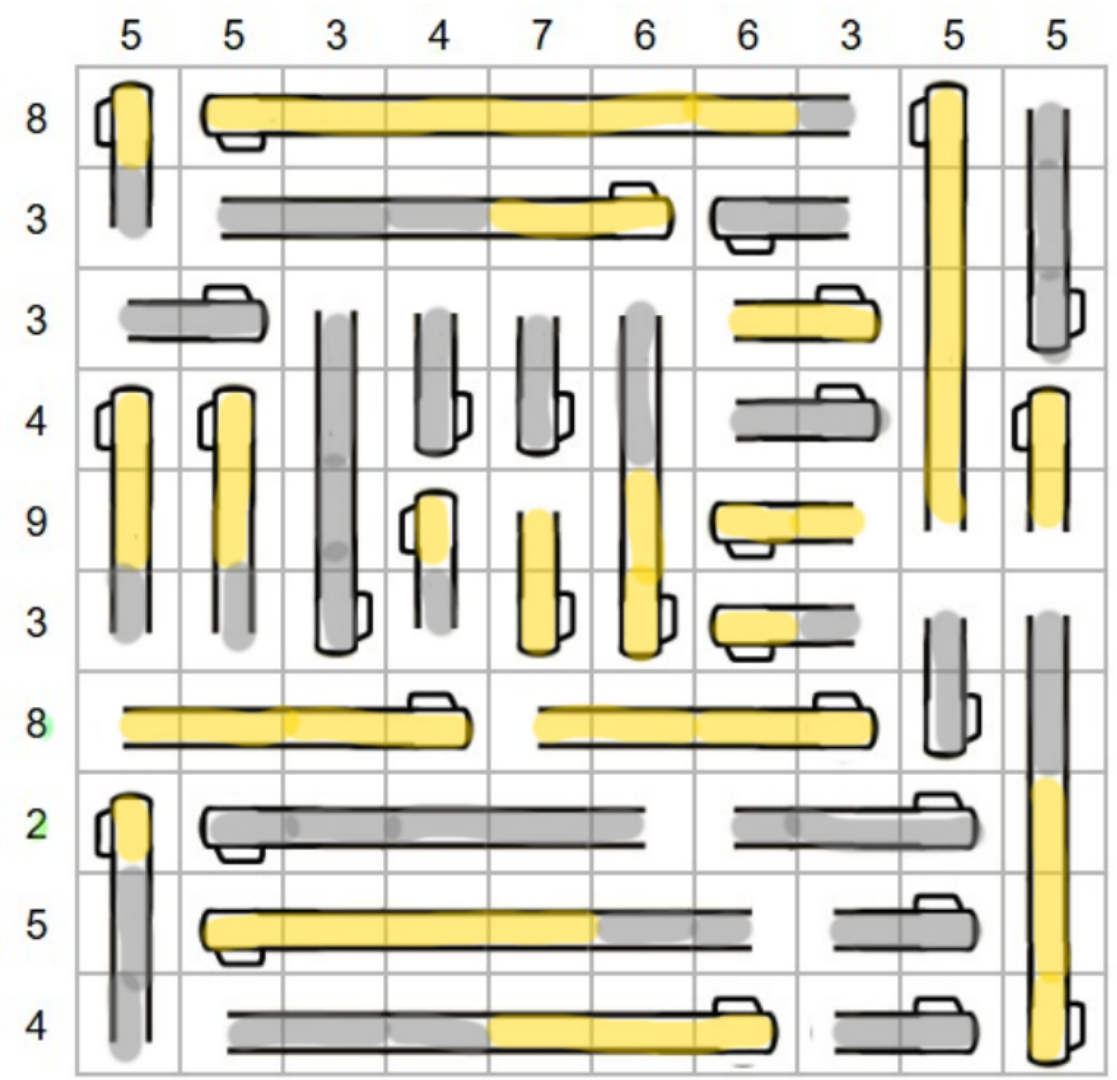


Tip: A good question to ask is how a "3" would affect the opposite tile. What about "2"? Try to draw the whole cube!

Send your solution to perio@fmf.nl to be featured in the next issue!

Solution to the previous Brainwork

AUTHOR: **R. MOL**



The previous puzzle was solved by Griffin Reimerink, Laurens Wiersema, and Max-Friso Schaap. Well done! Especially to Griffin, who solved the puzzle within an hour of it being uploaded online.

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