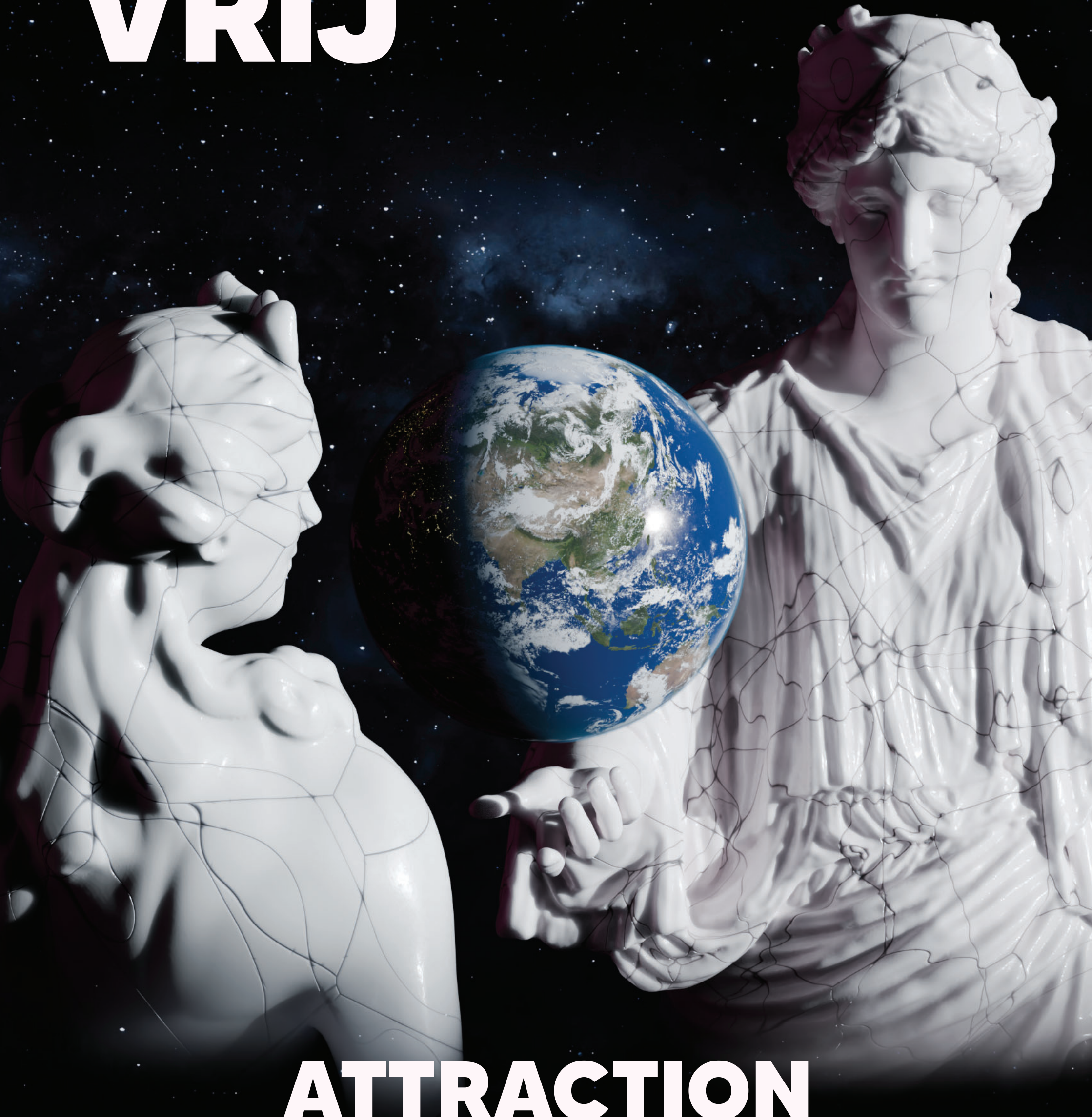
# FRANCKEN VRIJ

year 29 issue 1



# ATTRACTION

**Inside View**

2D magnets

**Theorist vs. Engineer**

The Future of Memory

**Romance Piece**

Scientific Analysis of Attraction


Francken Vrij
Equilibrium
Francken Vrij
Universe
Francken Vrij
Silver
Francken Vrij

# Colophon


## Editor in chief
Hannelys Posthumus

### Editorial board
Malo Blömker
Omar Gutierrez Laafou
Zoltán Hermann
Eline Mijnlieff
Tania Ovramenko
Bradley Spronk

## Senior Editor
Gerrit Boonstra


## Editorial
If you've explored previous editions of the Francken Vrij magazines, you may have already noticed something new: a fresh, redesigned attracting cover template, thanks to Bradley! This year, our lovely Commissioner of Internal Relations inspired both new and existing Francken members to join various committees, including the Francken Vrij committee. Together, this motivated group of creative and dedicated individuals has crafted the wonderful magazine now in your (e-)mail. Enjoy reading this edition, and we look forward to bringing you the next one!

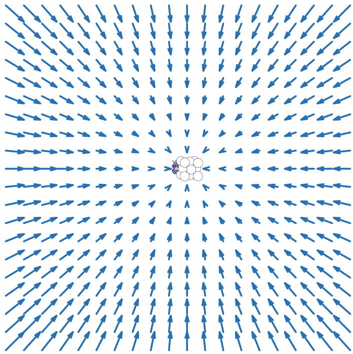

## Address:
T.F.V. 'Professor Francken'
o/c Francken Vrij
Nijenborgh 4
9747 AG Groningen
The Netherlands
Telephone number: 050 363 4978
E-mail: franckenvrij@professorfrancken.nl



## General:
**Advertisers**
ZIAM
**ISSN:**
2213-4840 (print)
2213-4859 (online)
**Edition and circulation:**
December 2024, 100

## Special thanks to:
Adriana van Harten, Samer Kurdi, Tim van de Vendel, Francisco Gonzalez, Zoltán Tajkov

# Edition 29.1



# Chair's preface

By Adriana van Harten

**Hello beloved member,** I hope you have survived the new academic year thus far whether you're studying or just living life. I hope that you have discovered something new about yourself, something you like and something you dislike, perhaps something (or someone) you are attracted to. For example how you may have been attracted to read this Francken Vrij about well... attraction!

Newton's law of attraction states that the force between two objects is proportional to the product of the masses of the two objects and inversely proportional to the square of the distance between the objects. Now, this law can be applied to Francken. Consider the first mass to be the average Francken member. Consider the second mass to be Francken as an entity, to do this we must calculate the mass of all Francken members plus the mass of the Francken room. I postulate that the average Francken member weighs somewhere around 72 kg and with 1200 members that equals a total of 86,400 kgs, easy. The Francken room however is a bit more complex; I had to turn to the internet for more insight on this figure. According to Roger on Quora.com who moved his house (and is American so pardon the use of imperial units), his single story approximately 24 foot by 36 foot (864 foot squared or 80.3 metre squared), fully furnished home weighed 26 tons (or 23,596 kgs). This works out to be 293.7 kgs per metre squared. Approximating the Francken room to be seven by six metres, 42 meters squared, it would weigh 12,335.4 kgs. Taking this weight plus the one of the Francken members it can be found that Francken as an entity has a mass of around 98,735 kgs. Now for the distance between you and Francken? Well it's zero! Since you are part of both mass A and B. Thus, force between you and Francken, or any Francken member is undefined but should be approaching infinity!

I'm sorry I led you on with all of these calculations just for the answer to not even have be rational, but I hope you enjoyed this nice review on the law of attraction and can carry it into reading this edition of the Francken Vrij. Happy reading!

# News of the Association

By Gerrit Boonstra

**Were someone to** ask me what activities Francken organized in the past months, I would just say: "yes", because we organized a whole lot, and I think there was truly something for everyone's taste. Unfortunately I can't describe them all in detail, because if I did, we would need another layout weekend, but I hope I can summarize some of the highlights!

**Bradley's week**

After the success of last year, Bradley was so kind to organize a week of activities again for any members who could not go all summer without seeing their fellow Francken members. There was a BBQ, a silent disco, a bake-off and we even followed a Bob Ross paint-along, among other things! The paintings are up in the room now, so be sure to check them out if you haven't already!

**Pienter camp**

To start the year well, Francken, FMF and Sirius A organized their yearly introduction camp again, and it was a great success. Here the first years got to know each other and engaged in some fun activities, like a sports day, a fox hunt, karaoke, kalashnicup and of course *vlaby*! To everyone's surprise, the beer was finished by the end of the weekend, so I think the first years (and of course the crew) enjoyed the camp to the fullest!

**Introduction week**

During the first week of the academic year we once again tested how many first years can fit in the room by handing out free toasties. Many students came to have lunch in the room, and in doing so got a taste of what Francken is like. Next to this we also organized the annual pubquiz together with

FMF and Sirius A, as well as a treasure hunt across the campus which we followed up by a karaoke night that same evening. During the treasure hunt, the first years discovered the campus and engaged in fun challenges, and the karaoke night was just that: a nice karaoke night.

### Start-of-the-Year-BBQ

The Start-of-the-year-BBQ was a nice demonstration of Murphy's law, because just about everything that could go wrong, did. The weather was horrible, the butcher forgot that we had placed an order, and due to an asbestos leak after a collapse in the beautiful gebouw 13 we could not reach our party tents. Despite all this, there were still many people who showed up, who enjoyed plenty of nice drinks, unlimited ice-cream and once it finally arrived, some delicious food. Hopefully the weather will be more favourable next year, but we still think this barbecue was a success.

### Francken Friday Lecture

The first Francken Friday lecture of the year was given by PhD student Xingpeng Xu, from the Optical Spectroscopy of Functional Nanosystems group. We enjoyed a nice talk about the ultrafast coherent control of excited state dynamics of organic conjugated polymers at room temperature and also some snacks and drinks.

### Bingo night

The first Fraccie activity of this year was a bingo night. We turned it into a drinking game, which was fun, and there were some nice prizes (of which I won two!).

### Beer mile

Sportcie organized their first event of the year in the form of a beer mile. This is a race where you have to run a mile and drink 4 beers inbetween. It was initially rescheduled due to an exam and poor weather. The day that it was moved to had great weather, so this was a great decision, and the beer mile was well-enjoyed by the participants.

### Lustrum

On the 12th of October, T.F.V. 'Professor Francken' turned 40 years old. To celebrate this, the lustrum committee organized a week full of fun activities leading up to the association's birthday. There were several parties, a brunch, a bodybag borrel (altough in the end we used cardboard boxes), a cocktail workshop and much more. It was not just a week of fun though, as there was also a murder mystery going on in between the activities. It turned out that the chair of the committee himself was the murderer, but luckily it was all just a show and the whole committee is still alive.

We also had an amazing gala at de Loods, where everyone dressed up nicely and had a great time. We enjoyed a symposium on nuclear fusion, with speakers from DIFFER, the University of Eindhoven, our own university and NRG PALLAS. It was chaired by our honorary member, prof. Jeff De Hosson, who gave a nice talk about the history of Francken, as well as an enlightening talk about entropy. After this there was a cocktail workshop at Buurten bij Bernlef, where our members mixed some tasty drinks.

On the Friday of the lustrumweek we had a bouncy castle and an obstacle course on the field between the Energy Academy and Linnaeusborg, which was super fun. That same evening we went to Spheer.ai for a Crash & Compile, where members either racked their brains about how to solve tricky coding problems or drank (or both).

**Intermediate GMA**

On the 15th of October the 40th board organized their first GMA by themselves. Obviously there were many motions and the board learned a lot. The final settlements of board Freefall and Buixie were presented and approved, as well as the annual report of Freefall. The board members of Freefall were hammered out and the members voted that they can remain permanent members of the association.

**Oktoberfest borrel**

On the 17th of October Borrelcie celebrated the beautiful tradition of the German Oktoberfest with a cozy borrel. There was German beer, German Bratwürst and German music. The Bratwurst was very tasty, and so was the Paulaner beer (although I would not recommend drinking it in quantities of one liter) .

**ASML lunch lecture**

On the 21st of October, together with our brothers at FMF, we enjoyed a tasty lunch while a representative of ASML talked about what ASML does and what it is like to work at the company.

**Movie night**

On the 22nd of October Fraccie organized a movie night in one of the lecture halls of Nijenborgh. We watched the Dictator, and since people still wanted more after that we watched Oceans 11 as well.

*Two German gentlemen celebrating Oktoberfest (they are not really German, though)*

# 2D Magnets, a New Class of Magnetic Material

By Samer Kurdi

**I don't know** about you, but my fridge door is covered with photos of friends, family and drawings by nieces and nephews. Like many of us, I use magnets to keep these wonderful memories on the fridge door.

Magnets are fascinating objects which we have known about since antiquity which attract certain materials. Since then, magnets have helped use navigate the globe, harness energy, revolutionize medical imaging and even enabled global access to data. More on these applications later.

**How do magnets work?**
A simple picture is that a magnet has two poles, a south and a north pole, in which the north pole of one magnet is attracted to the south pole of another, while like poles (north to north or south to south) repel each other. The result is what is called magnetic attraction and repulsion.

Now for the added complexity. A magnet is not actually broken in two parts, the north and south poles. Rather a magnet is composed of many tiny magnets which we call spins. These spins are part of the electron, which is a negatively charged particle. This is part of an atom and is the building block for electricity. Materials are made of many atoms, these atoms have electrons and these electrons carry spin, which makes them atomic sized magnets or compasses.

Now you may ask what makes a material magnetic? And why if all materials have electrons why are they not all magnetic? Well, imagine these spins as randomly oriented compasses. In most materials, these compasses point in random directions and cancel each other out. In magnetic materials, the majority of these tiny compass needles point in the same direction and their collective orientation creates a magnetic material with a net magnetization. Some noteable elemental magnets include iron, nickel and cobalt.

**How does a magnet keep my picture secured on my fridge?**

Some materials are not magnetic but they can be magnetized when a magnet is brought nearby to them, like your fridge door. A magnet emanates a magnetic field, this field makes the surface of the metal fridge door magnetized which creates a magnetic field of its own, these fields interact resulting in an attraction. This process is reversible as once you pull the magnet off the fridge surface, the fridge door is demagnetized. This effect is very small in this example which is why you can only hold light objects like pictures or notes.

**How are magnets important for my day-to-day life?**

Outside of fridge magnets, an important utilising magnetic properties is the compass, a tool vital for human navigation. This tool is very simple as it has a magnetic needle that aligns with the Earth's magnetic field, which indicates the direction. And yes, the Earth is a magnet due to its molten iron core.

In our everyday lives we use magnets in screwdrivers to make working with metallic objects easier, we see them in the healthcare sector as major components of MRI machines, to get detailed images of the human body. They are also crucial for electricity generators, converting mechanical to electrical energy.

Personally, I am more interested in how magnets can be used for information technology and devices. They have already revolutionized our data storage capacity. The hard disk drive in computers is composed of a magnetic disk with many tiny magnetic regions and a tiny magnetic sensor on a tip. The sensitivity of this tip has been improved over the years allowing the detection of small changes in magnetic field on the disk, generating more dense data storage, which is crucially important as our information society has sky rocketed. For the historians out there, the breakthrough for this sensitive magnetic sensor came in the 1980s from the Nobel prize winners Albert Fert and Peter Grünberg.

**A new exciting class of magnetic materials discovered!**

In 2017 a new class of magnetic materials was discovered, which set the field of material physics ablaze. These magnetic materials are called 2D magnets, in which they can be mechanically broken down to single atomic layers forming a truly two-dimensional material.

This sounds a bit weird and complicated… what do I mean by two-dimensional materials? and what do I mean by mechanically breaking down to a single atomic layer?

**What is a 2D material?**

I think it is important first to explain what a 3D material is or simply what a normal material is. 3D materials are just regular materials around us, wood, metal, plastic. These objects have a length, width and depth. A 2D materials is different, they only have a length and width and no depth, so they are incredibly thin. Think of a sheet of paper and dividing its thickness by 100 000 times.

These materials are one atom thick. Even as someone who works in this field, I find this fascinating to think about.

The most common 2D material is called graphene, which is made of Carbon. Carbon is interesting, as it has many forms, like diamond and graphite (which we use on a day to day basis, for example in our pencils).

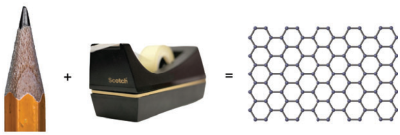



*Figure 1: 2D material in the lab*

**From graphite to graphene**

These materials are made of sheets which are weakly bonded together via electrical attraction. You can think of these materials as post it notes, in which each layer has an air gap from the next, but the whole forms a solid block. These gaps between layers form because of a very weak electrical attraction called van der Waals forces, names after Dutch scientist Johannes van der Waals. As these forces are weak, Noble prize winners Andre Geim and Konstantin Novoselov realized in 2004 that simple scotch tape…yes, scoth tape…can break graphite down layer by layer until they isolated a single atomically thick layer of Carbon, which we call graphene. Back to our post-it anology; they peeled each invidual post-it note until a single post it note is left, forming the two-dimensional material graphene.

This was not all. What they realized is that this material had significantly different properties to its bulk counterpart graphite. It was more conductive, more flexible and was stronger. There was a lot of new physics to explore.

**But why does removing the depth of the material and going from 3D to 2D change its behaviour?**

There are various reasons, one main point is that particles in materials when in 3D have much more space to avoid each other. They can go left, right, up and down. But now in 2D, particles can only go left and right and therefore interact more, creating what physicists call emergent phenomena. Essentially by adding dimensions, we remove interactions and by taking dimensions away, we make stronger interactions.

**What is a 2D magnet?**

Now since we know what a magnet is and what a 2D material is, its much simpler to define a 2D magnet, which is really a magnet that is one atom thick. Just like graphene, we use regular scotch tape to break down a bulk material down to a single atomic layer. Once we reduce the dimensionality we observe interesting effects just like in graphene.

**What makes 2D magnets special?**

First and foremost, the fundamental physics is important to investigate as these materials behave in ways normal magnets do not.

But I think to answer this question more clearly and to give more context, it is important to introduce what the challenges are in modern technology. Magnets, like I said, are used in data storage-type technology and even offer alternative computational frameworks. However conventional technologies cannot keep up with the demands of our ever increasing information society: the processing needs of the planet include increased storage capacity, compact devices, and energy efficiency. As an example, many consumers are looking for smaller, more powerful cell phones which do not consume as much battery power.

Keeping this in mind, the first reason 2D magnets are interesting is because of miniaturization. This one is easier to explain; theoretically, by scaling down from 3D to 2D we can make compact 2D nanoscale devices which lead to more compact electronic components.

Secondly, using 2D magnets can theoretically be more energy-efficient. This concept is a bit more difficult to explain, but as mentioned earlier, electrons carry spin. Unlike electrical current caused by moving charge, which can generate heat, spin can also be moved around, which creates a spin current. This spin current has the additional ability that it does not generate heat. So theoretically, by moving spin instead of charge, we can make devices more energy efficient, and spin current is mainly possible in magnetic materials.

Thirdly, these materials are highly tuneable. But what do I mean by tuneable? These 2D materials can be stacked on top of each other, like post-it notes (and even twisted on top of each other) to create new emergent behaviour, which each individual layer did not have. This attribute unlocks the ability of potentially creating new ways for manipulating computational devices.

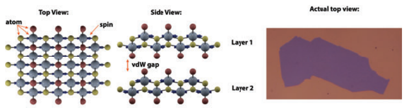



*Figure 2: Schematic of a 2D magnet*

**How come they are not already in my phone already?**

While these breakthroughs have excited the field and the theoretical applications of 2D magnets are very exciting for future data storage solutions, the research is still fundamental. Our aim as scientists today investigating these 2D magnets is to understand more about how they work to see how they could be used in actual applications in the near future.

There are also manufacturing and compatibility challenges. We cannot currently make high quality wafer scale of these materials, as using scotch tape only enables micron-sized samples in the lateral dimension. Moreover, current technology often relies on established materials and components. Integrating 2D magnets may require changes to existing technology, which can be complex and costly. This is important for commercial viability and for keeping costs down.

In addition, most 2D magnets operate at temperatures well below room temperature and require cryogenic liquids to cool them. Many theorticians and experimentalists are working towards realizing more room temperature 2D magnet variants, but this is currently a key part of working with 2D magnets in a lab.

In scientific terms, this is a very new and exciting field, with 2D magnets having only been discovered in 2017. For me, this fundamental phase of research is incredibly exciting, as there are many 2D magnetic materials to explore and diversity with all types of magnetic behaviour and functionalities.

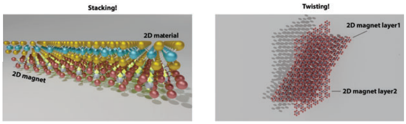



*Figure 3: Tunable properties*

## Last words

In sharing this blog, I hope to have introduced the world of magnets to you in addition to the current state of the art of magnetic materials. I am amazed by this field of physics research due to the fascinating properties of magnetism in the atomic scale and the potential for emergent phenomena.

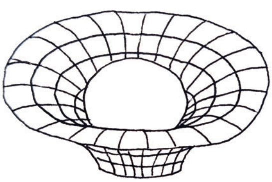
I would like to thank my funder, the Dutch Research Council (NWO) via VI.Veni.222.296, for providing the resources to do this wonderful and exciting research. I also guide you to check out a previously recorded podcast[1] on quantum magnetic materials which I was a part of, and which inspired this blog.

[1]Link to the podcast: tps://www.youtube.com/watch?v=2R3C9HVS-Jk

# ESA's Frontier in Relativity: Pushing Limits of the Theory

Interview with Francisco Gonzalez
by Tania Ovramenko & Malo Blömker

**Attraction is always** around us. Take the most basic thing, gravity - the most fundamental interaction in our universe that brings everything together. Attractional force, a consequence of the curvature of spacetime, call it what you want, it is the most significant force on the macroscopic scales whether it is making an apple fall on Newton's head or bringing stars and galaxies together. Einstein was the one who grasped the concept of gravity in the most detailed way by stating that spacetime is curved by matter. He called it a general theory of relativity, where there is no force as such, but a field, a gravitational field. We can imagine this field as a trampoline and set a heavy object in the middle. The fabric of the trampoline curves under the weight



of this object. When launching a smaller object, such as marble, around the edge, it would spiral around the heavier body just like planets around the Sun (this comparison has some imperfections, but it is the easiest way to visualize the gravitational field).

So far, the experiments we've conducted confirm Einstein's theory, but of course you can never prove a theory fully, only test its limitations or disprove it. General relativity (GR) predicts many effects within its theoretical framework. One of the classic tests of the GR is observing the gravitational redshift, specifically measuring it with high precision using atomic clocks.

First of all, let's figure out what gravitational redshift is. Theory predicts that the wavelength of the light should become longer as it climbs out of the gravitational potential well created by a mass. As photons at the speed of light are trying to escape, they lose energy while keeping the same speed. The loss of energy is reflected in the decrease in frequency which shifts the light to a redder part of the spectrum.

Testing this effect could be done using already existing at-hand technology - a global navigation satellite system (GNSS). These satellites carry very precise atomic clocks on board and exchange signals with the receiver on Earth, while accounting for various corrections. The clocks are utilized for scientific research, which is exactly what a team at the European Space Agency did in 2018. To find out more about this application of a GNSS we contacted Francisco Gonzalez who is a Navigation Engineer at the ESA. He was part of a team working on Galileo - GNSS created by the European Union. "My main work was related to precise orbital clock determination of Galileo satellites," reflects Francisco. The team effort was concentrated on the use of the two satellites which were accidentally delivered on elliptical orbits instead of circular. "It was not intentional. It was a failure during the launch", but this mistake allowed scientists to push the precision of the violation parameter to a higher order. Francisco himself was "in charge of the part of the corrections that were applied in the system".

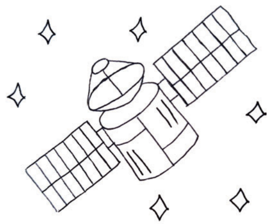
Advances in the development of the atomic clocks made the GNSS technology possible. The system accounts for both special and general relativity to give users their precise position. What is being measured is the time of the signal transmission between the clock on the satellite and the clock on the ground. This transmission time is affected by GR effects. "Three basic principles of general relativity need to be applied to make the GNSS work", says Francisco. They are introduced to the system as corrections. The key correction is "a frequency offset that we need to apply to the transmitting clock of the satellite to correct the initial frequency that you see from the ground". The clock on the ground is set to a frequency of 10.23 MHz. To ensure that the clock on the satellite is ticking at the same rate, the factory offset of around 4 mHz (yes, so small!) is applied to lower the frequency and compensate for this relativistic effect.


The second correction is called periodic relativity correction and it reflects the fact that the velocity of the satellite is not constant as in the case of the elliptical orbit: it is not circular and the velocity is changing. "The two satellites that went to a more elliptical orbit become a unique occasion to use this second correction" which allows us "to use this non-constant velocity to measure the general relativity [violation parameter] with the precision that was better than what was possible at the time".

The last, third correction is "due to rotation between two different coordinate systems", it is called the Sagnac effect correction which accounts for the rotation of the Earth and the differences in the perceived velocities due to this rotation. In this way, all the basic principles of general relativity are used in modern navigation systems.

Taking into account all these factors, the results that were obtained "did not change the general relativity assumptions". "What we did was measure with a precision that was higher than the one achieved at that time…unprecedented precision", noted Francisco. "[Field] is evolving and there is a new technology that is based on optical clocks… At the moment we are looking at the precision on a fractional frequency that is $10^{-14}$ - $10^{-15}$ with the passive hydrogen maser, with the optical clock they are looking into $10^{-18}$ - $10^{-20}$… We are still a little bit far from that today for space applications, but in the future, in 20 years, it could be possible. But it is a very interesting area of work".

"All the GNSS satellites have an engineering objective: that is to provide navigation product. But from the other side, each navigation satellite can be used to do scientific observations to meet scientific needs. That is done normally for all the satellites, but in this case, it was possible to use this elliptical orbit "to increase the precision and test the limits of GR even further. "Of course, if there are other [similar] events, you will try to use them as much as possible to gather as much scientific knowledge", concluded Francisco.



He also told us about his current research: "I've been moving from project Galileo to the Gravity experiment… next generation Gravity. I still keep an eye on the second generation of Galileo, there is a new technology for the atomic clocks that I am quite interested in seeing fly in the future. While the Galileo 2nd generation is based on improvements of the designs from the first generation, there is the possibility to fly additional experimental clocks".

When asked about possible prospects for applied physics students in this area of research, he shared that "with applied physics and applied mathematics you can be involved in any project…I think you can work in any aspect [of this research] because you have things on thermal, electronic, signal, orbit determination, and flight dynamics, there is physics everywhere in space… it is up to you to decide what is in your best interest". "Space is always a very interesting area of work. Also in the last few years, there has been a strong move from institutional to commercial use of space… There are many new applications that are coming… The number of launches we had when I joined ESA is not the same number of launches we have today", noted Francisco implying that right now it is significantly higher.

To close our conversation we asked Francisco to give some advice to students, and here is what he said: "If you want a recommendation, I just want to encourage students to do a PhD on some specific subject. It is always very good to gather knowledge in one area to push it to the limit and then decide in which company you want to work later that is working in that area. It is good to move to a company, and it is good to move to an institutional organization. Working in a university for a while is a good way of looking at something you really like. In the university, you can focus on pushing something new to the limit. When you are in the company, you need to work to develop the product that your company is producing. You have more freedom in university… you have your area of research and you have more freedom to concentrate on one specific aspect. If that specific aspect is innovative then you will find always opportunities to work in that area".

*References*

*[1]Delva, P., "Gravitational Redshift Test Using Eccentric Galileo Satellites", Physical Review Letters, vol. 121, no. 23, Art. no. 231101, APS, 2018.*

*[2]Herrmann, S., "Test of the Gravitational Redshift with Galileo Satellites in an Eccentric Orbit", Physical Review Letters, vol. 121, no. 23, Art. no. 231102, APS, 2018.*

# The future of memory

By Zoltán Tajkov & Zoltán Hermann

**Magnetism, as a** force intrinsic in the fabric of nature, has fascinated scientists for long and has been an essential part of life. From compasses guiding explorers around the world to the hard drives running everything in the digital world, magnetic materials are integral in shaping modern life. They are unnoticed to most people, yet still make everything possible, such as you reading this exact article.

Ever since the discovery of graphene, the interest in two-dimensional, so-called van der Waals materials has surged. These atomically thin materials have interestingly unique properties, much different than their bulkier counterparts. Their potential spans everywhere, from ultra-efficient electronics, flexible displays, and advanced sensors to atomic-scale Lego bricks, if you'd like to play sometimes. 2D materials can also be stacked in tailored structures, unlocking new possibilities for niche applications—whatever your mind can think of!

At the intersection between magnets and 2D materials, there is a promising new area of research. Nanoscale, topologically protected spin textures called skyrmions exhibit unique properties and are quite promising in next-generation spintronic devices, such as high-density and performance memory devices. Due to their innate thinness and robustness, they are ideal to be layered. And, with magnetizations as information carriers, they are superior to traditional semiconductor technology considering efficiency and endurance to disturbances, such as radiation and thermal fluctuation.

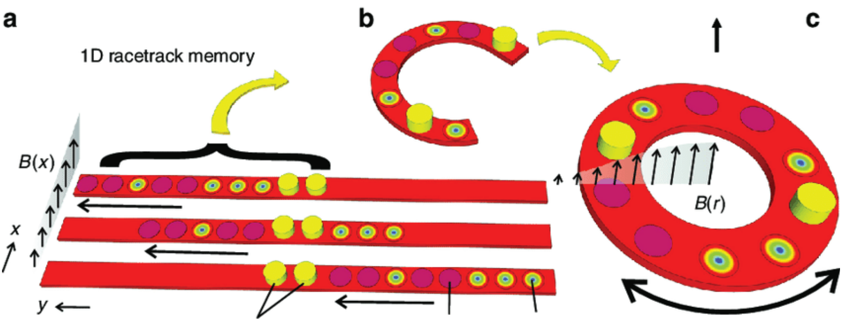



*Figure 1: Straight and circular skyrmion racetrack memory.*

*Manipulation of skyrmion motion by magnetic field gradients - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Circular-skyrmion-racetrack-memory-concept-a-In-the-1D-skyrmion-racetrack-memory-scheme_fig1_325426601 [accessed 9 Nov 2024]*

Skyrmion racetrack memory is a promising type of memory device that uses these properties to its advantage, enabling high-density, energy-efficient storage. The information is stored by the presence or absence of skyrmions along a nanometer-wide magnetic track. Each skyrmion represents a bit, and the whole line of skyrmions is shifted along the track for heads to read or write data.

As skyrmions are fundamentally different than conventional ferromagnetic materials, anticipating their behavior is a huge challenge, but one that needs to be solved to harness their potential. The motion of skyrmions is driven by two types of torques, which lead to their superiority.

Spin-transfer torque (STT), generated by the flow of a spin-polarized current, transfers its angular momentum to the skyrmion, giving it the ability to move without requiring a large current density. This allows it to function with such low power consumption.

Spin-orbit torque (SOT) arises between bilayered metals, such as a heavy metal and a ferromagnetic layer. SOT requires even less energy than STT; therefore, more efficient control can be achieved.

To model these motions, the Thiele equation is used, where a skyrmion is modeled as a quasiparticle, incorporating gyroscopic forces, which arise due to the skyrmion's topological charge. This equation is able to predict the movement of skyrmions under applied currents or fields while accounting for the effects of gyroscopic coupling, which lead to the skyrmion Hall effect.

The skyrmion Hall effect is caused by the topological charge, causing skyrmions to move transversely when driven by a current. This behavior presents a big problem in practical applications, as positioning the skyrmion is a big challenge in confined memory tracks. Researchers are working hard to mitigate this effect and achieve more stability, by creating antiferromagnetic skyrmions or creating specially patterned materials that pin the skyrmions in place.

Other problems with stability in skyrmions result from their nature of varying their structure depending on the Dzyaloshinskii-Moriya interaction's direction relative to the magnetic field. This forms types like Bloch skyrmions (with spins rotating perpendicular to the radial direction) or Néel skyrmions (where spins point radially inward or outward). In some materials, even a mixed type of skyrmion can be observed. Achieving these structures to be stable at room-temperature operation is a significant area of research, as so far, most materials remain stable at cryogenic temperatures. [1]

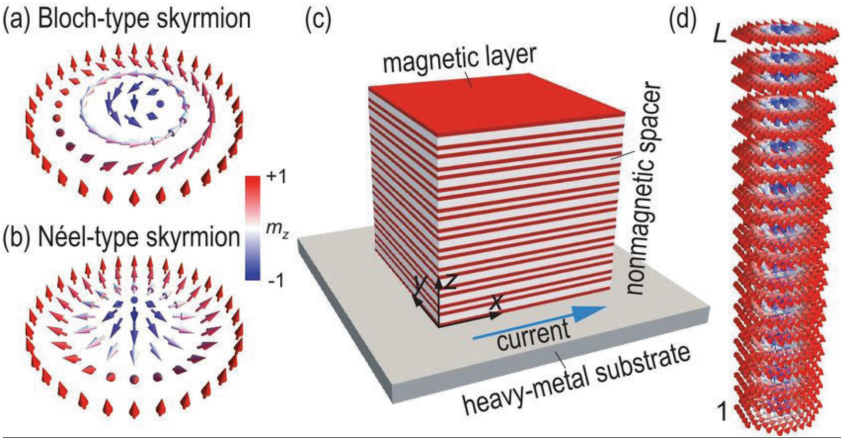



*Figure 2: Schematic overview of skyrmion structure, and layered material*

*Nonlinear dynamics of topological helicity wave in a frustrated skyrmion string - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/a-Schematic-of-a-Bloch-type-skyrmion-b-Schematic-of-a-Neel-type-skyrmion-c_fig1_359575676 [accessed 9 Nov 2024]*

Room-temperature stability is trying to be achieved by using material engineering, where 2D magnetic materials are layered with heavy metals that introduce defects to pin skyrmions in place and create synthetic antiferromagnetic structures. Additionally, techniques like strain engineering, ion implantation, and selective doping are being used to achieve specific properties that help the stability of skyrmions. [3, 2]

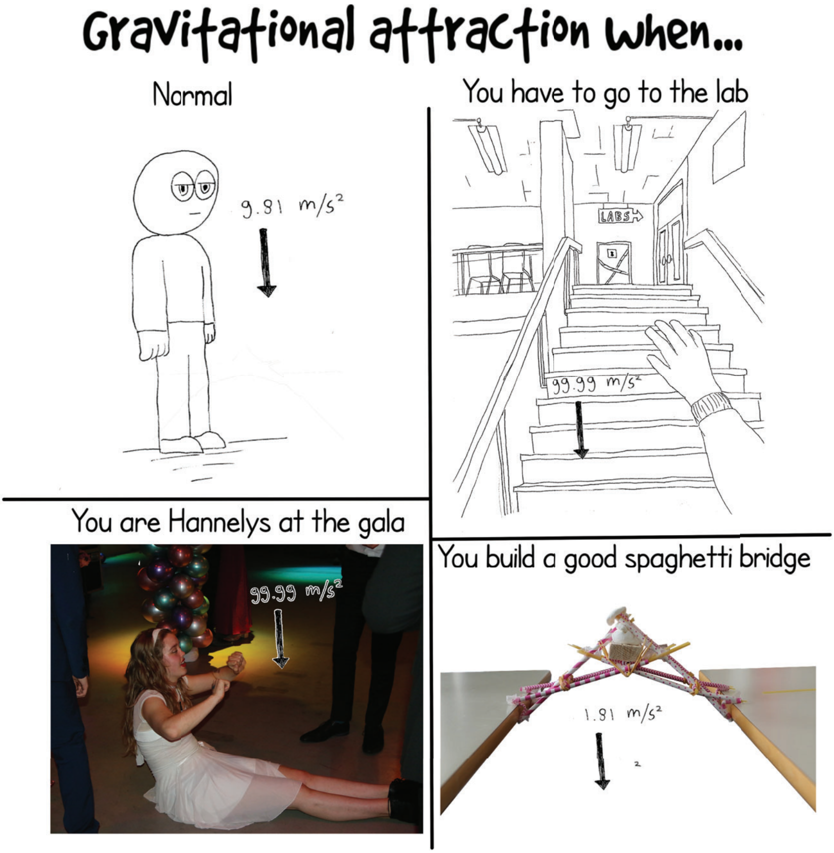
All of these efforts bring us closer to having consumer-grade technology using skyrmions that we could only have dreamt of in the past.

## References

*[1] Yuto Ohki and Masahito Mochizuki 2025*
*J. Phys.: Condens. Matter 37 023003*
*[2] Roland K. Kawakami, The Ohio State University 2020, Spin and Magnetism in 2D Materials*
*[3] Ranjan Sahu, Dipti (editor) 2021, Magnetic Skyrmions*

# Comic

By Gerrit Boonstra



# Measuring the super-heavy, super-precisely

By Tim van de Vendel

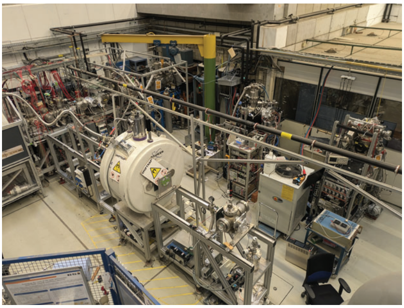
**Hi there!** My name is Tim van de Vendel and a lot of you will already know my face from all the countless coffees I've drank in the Francken room. In July of this year, I officially completed my bachelor in Physics. Given that I am, at the time of writing, still younger than some of the sjaars, I decided to take a gap year before starting my master's. Of course, no one in their right mind would stop doing physics for a year, and that is how I ended up doing an internship in Darmstadt.

Specifically, I am working at the 'Gesellschaft für SchwerIonenforschung' ('Institute for Heavy Ion Research' if your German isn't that great). It is a research centre that focuses on all things involving heavy ions, from radiation therapy to nuclear research; think CERN, but the projectiles in our accelerator are a lot more massive than in the LHC. The group that I am in is kind of like the postcard of the institute: the super heavy elements group. We effectively focus on all things beyond uranium. In this very group, SIX new elements were discovered in the last thirty years (including Darmstadtium, and I bet you can guess where that name comes from). Our focus lies in the characterisation of these elements, meaning we determine their mass and electron energy levels.

Now, to any applied physicist this will immediately raise the question: that sounds useless, what can we actually do with that? Well, if I'm truly honest: not much at the moment. As with most fundamental research, the true motivation is going where no one has gone before. I work in the spectroscopy group. Since the elements that we work on have over a hundred electrons and more than twice that amount of nucleons, their wavefunctions are extremely complicated and only modelled approximately by the theorists. By measuring the transitions between the electron levels very precisely, we can also determine all sorts of information about the correctness of our models and what our nucleus looks like, studying for example its spin, spatial deformation and stability.

For those of you who never took Atoms & Molecules, I will quickly go over the workings of the spectroscopy setup. A high-energy beam of heavy ions, typically Ca-48, is sent onto a rotating target of an even heavier element, for example lead. Upon contact, these fuse to form all sorts of super-heavy elements in excited states. These products decay, and some of the decay channels give the specific element that we are interested in, which happens typically at a rate of an ion every few seconds.

If you want to perform spectroscopy, you better make sure that your ion turns into a neutral atom, or else all your energy levels will be shifted. Hence, we guide the ions of



interest onto a so- called filament, where they are absorbed and neutralized. This filament is subsequently heated in a burst to a few thousand Kelvin: the atoms boil off and form an atom cloud around the filament. We then bomb this cloud with two lasers: one of them is tuned specifically to (or to be precise, scanned over) the transition that is to be measured, while the other has an energy that is just enough to ionize the atom if the first laser was successful in exciting the atom. If we manage to produce any ions, we then guide them to a detector piece. If we measure a signal, that means the wavelength we scanned over is the right one for that transition.

You might think this is all a bit too fundamental for the average Francken member, but the methods used actually reflect a lot of skills that you need as an applied physicist. The first few weeks of my internship were spent learning technical sketching software, working with ion simulation programs, cleaning vacuum pumps and fighting lasers to work. So I guess this 'theoretical' physicist has finally succumbed to some of the peer pressure in the Francken room and gotten his hands dirty.

Moving to Darmstadt has been quite the experience. If you have ever been to a

*"I spent my first week fighting lasers and cleaning pumps"*

mid-sized German city, you will know that these cities are not known for their vibrant streetscape.

Additionally, Darmstadt suffers from being extremely ugly as it is a very industrial town, in contrast to the beautiful neighbouring Heidelberg for example. That has its advantages though: there is an absolutely massive TU here, as well as a huge Hochschule (university of applied sciences). It actually

comes close to Groningen in proportional student population, and apart from GSI, the city houses the ESA operations centre and a few of the biggest pharmaceutical companies in the country.

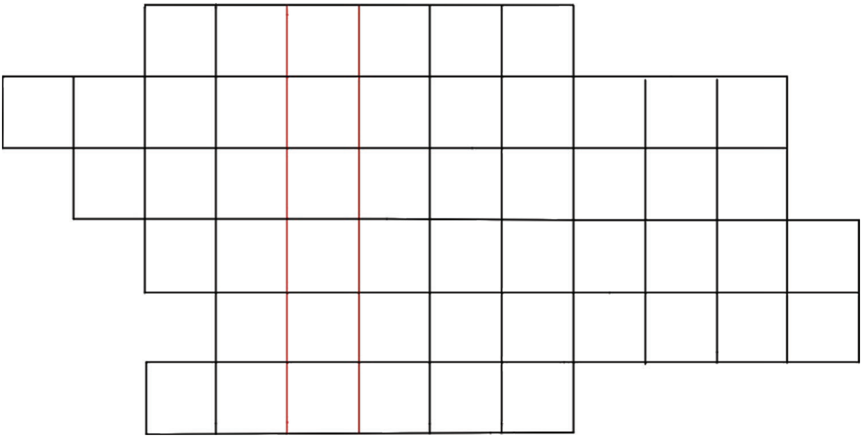
Though I do miss my friends and busy life in Groningen, my colleagues here have been very welcoming from day one. Drinking beer is naturally a big part of the culture (and let me tell you, the beer is really, really, really good), though not as much as I have seen in Francken, but in the first two weeks I had already seen the inside of the local 'biergarten' four times.

In a lot of things, Germany is quite similar to the Netherlands. The language is nearly interchangeable (if you try hard enough), there is not much of a cultural difference and my jokes luckily still land. A difference I have found, is that the work culture here is very thorough: everyone works hard and around the clock without question. Achieving project goals is number one on the priority list; expect no one looking at the clock when it's five to see if they can go-home already.

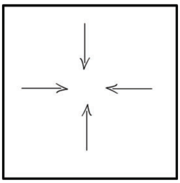
All in all, I can say that this internship has already brought me an enormous amount of experience and skills that I would have never gotten from my normal lectures and tutorials. For anyone who has the time (maybe despite the upcoming langstudeerboete), I can wholeheartedly recommend spending some time abroad and in the lab; it might be the best choice you make in your degree. Oh and Erasmus will gladly give you quite a large scholarship, but you didn't get that from me.

# Puzzle

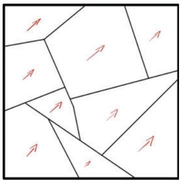
By Malo Blömker



1.



2.



3.


4.

5.

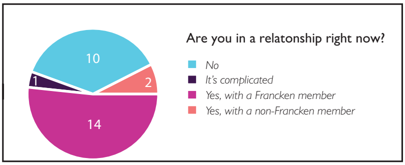
6.

# Scientific Analysis of Attraction

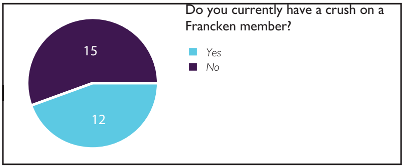
By Hannelys Postumus & Gerrit Boonstra

**Love can be** a difficult and abstract concept to truly grasp. Physicists have yet to come up with the equations that describe this complex phenomenon of attraction between two people. To aid in this cause, the Francken Vrij committee embarked on a statistical analysis, for which they asked the active members of the association to answer a short questionnaire. With a solid 27 responses, we hope to find some underlying pattern that can be of use to anyone voyaging the rose-coloured mists of the dating world.

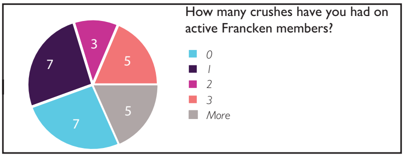
Firstly, we asked them if they are currently in a relationship. No less than 10 active members are in a relationship with another Francken member! We are sorry for the one person whose situation is complicated. We're sure it will be better soon.



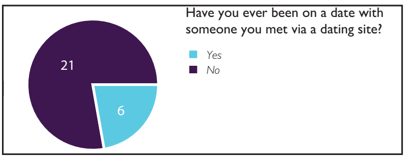

It is interesting to compare this to the answers to the question 'Do you currently have a crush on a Francken member?'. There are twelve people who currently have a crush on a Francken member, while only ten people are in a relationship with a Francken member. Who could these people be?



Next we asked you how many crushes you've had in total on Francken members, the results of which you can see in the pie chart below. If we assume that the members who said 'more' had on average 5 crushes on Francken members, then a quick calculation shows that the average Francken member has had around 2 crushes on other Francken members. This means that statistically speaking, if you are a Francken member, someone has or has had a crush on you! Or maybe there are just a few lucky people (probably me) who have made several people fall for them.




Apparently, dating sites aren't very popular among Francken members. Only 6 out of 27 people went on a date with someone that they met on a dating site. It could also be that Francken members do use dating sites, but with a low success rate. For future research, it is recommended to first ask how many people actually use dating sites, such that this can be compared to the number of dates resulting from this, but we forgot to ask this.




Then, we asked our members what their biggest turn-ons and turn-offs are when they have a crush on someone. The responses vary wildly, but there are some common trends, and also some funny answers, which we would like to share with you. Common answers are things like eye contact, taking time out of their day to talk/hang out with you, and actively listening. Here, active listening means that they remember things that you have told them and can reference them later on. Some replies also speak of "that look they give you", which sounds like something that is just happening in your head, but okay. Flirting back/reciprocating feelings is also one of the answers. To be fair, if this is not the case you might want to stop having a crush on this person.

Some of the turn-offs were: when they act super different around their friends, them being cold or too distant, not taking good care of themselves or smoking. Someone also answered "I don't know how to say this without sounding like an asshole, but when they give me an unintelligent impression", which was directly followed by another response saying "lack of intelligence", and later "being stupid", so to whoever wrote the first answer: it's okay to be a bit more straightforward in your communication, other people seem to do it too

One of the answers was "When he farts in front of me", which I find weird. If your goal is to date someone on the long term, I feel like this is quite inevitable, unless you want your partner to slowly inflate over time until there is so much gas inside of them that they start to float like a balloon.

Several answers said they don't like it when their crush flirts or even talks with other boys/girls. This is understandable if you are dating them, but if you are not, then unless you ask them out, they have no reason not to. The last answer of note is "not being able to cut onions". I am not sure who wrote this, but if you are looking for someone, perhaps you had better practiced your onion cutting.

We also asked what the biggest red flags are according to our members. A lot of the replies are common sense (e.g. cheating, lying, arguing without a reason, etc.) and a lot of them were about politics for some reason. I get it, if your girl does not support the Frisian National Party, she should not be your girl, but unfortunately we will not be discussing these red flags in the Francken Vrij. A common trend though, was that if someone treats others in a way you would not want to be treated, you should not be with that person. Trouble in communicating was also seen as a red flag, as well as them not having clear goals in life. Some funny answers include: not knowing the abc-formula (I don't remember it myself either, since we don't use it much in university), confusing astronomy with astrology and "refusing to sit on my face", which I think is self-explanatory.

Now you know what to avoid, but it is also nice to know what signs point to someone being a potentially good match for you. For this reason, we also asked for your biggest green flags. To start this list off strong we have knowing the abc-formula, which is almost as important as being able to play klaverjas.

Having common interests was also a popular answer. Of course it is great to have this, but it is also nice (in my opinion) if the other person has their own interests, so you can learn a lot from them and discover new things. There were also a lot of sweet answers in here, and things that are very healthy to see as green flags, for example: being open minded, reflecting on your mistakes and being able to say sorry. Some cute points are being good with kids, being humble and remembering small details.

With this knowledge, it should only take you mere moments to get yourself a date. Now the question arises: where should you take your date? To help you out with this we asked our members for their best first-date ideas. Some of these answers we had to look up, only to find out that the locations mentioned are not real, or just some other way of saying bedroom.

Many of you would take your date out for coffee or some other drinks, potentially in a cafe that has board games or cats. Dinner was also a popular answer, as it is a true classic, just like going to a park. Some more active dates included Walibi, an arcade, mini golf and playing hide and seek in the Ikea. If you or your crush is an astronomy student, then stargazing at Lauwersoog would be a nice idea (although you can also do this as a physicist or mathematician). Someone also said they would take their first date to one of their lectures. Of course it depends on the course that you are taking, but I think this is potentially a bit boring, and it does not give you the chance to talk to each other.

Perhaps the best suggestion was the following: "I think a good first date has something active to do and a little bit of competition to make the nerves go away. Having some drinks on the first date also sounds fun, so I think going to the Tour de Francken sounds like the ideal first date."

This we can only agree with, and this seems like the perfect statement to end this column with. We hope that you learned something and we wish you all the best in your romantic endeavours. Kusjes, the Francken Vrij.

# Member's Input

By Zoltán Hermann

**Hi everyone! I'm** Zoli, a sjaars from Hungary, studying physics, although I'm trying to prioritise studying a lot of times, you will still see me at events with a beer in hand, as that's something I cannot pass up on. I don't want it to feel like I'm pouring my heart outhere, but I will have to really convey what Francken feels like for me.

Most places I've been at in life, I've always felt like I could not fit in, that something always made me not be accepted. With moving here this was a big fear of mine that it would be the case again, and I could not make Groningen my new home.

On the first day of school while getting a tour of this beautiful campus we were shown all the associations the FSE has to offer. I instantly felt a pull towards Francken, due to the energy and coolness of the members there. So I joined in that instant. During the first week of events I had already felt like I had made the right decision and found my place. The level at which Francken makes us little newcomers feel welcomed is unimaginable.

With the study load only ramping up I had plenty of time for fun, so I spent every day and night at the members room, where I was introduced and taught just a little bit of the immense amount there is to know about university, Francken and adult life. One important, or the most important according to some people is knowing how to play klaverjas, which I still have not been able to really do. It just baffles me how smart people are. But I love watching and eavesdropping on people talking about super advanced physics.

Also with this imposter syndrome starts setting in with being surrounded by so many bright minded people. To my suprise almost everyone here also experienced this at some point or another, and it's just a normal part of being a student. Therefore now I'm just embracing, and using it as motivation to study hard and to learn as much as possible from everyone.

On the other hand, Francken doesn't let you forget that you are still a kid even though most of us just moved away and started living on our own. Like with having a fun treasure hunt, we had the opportunity to get our competitive and adventureful side out, although it did include me doing my first batman chug. For the closing day of Lustrum week a bouncy castle was brought out, that I had to go to as I can never not say no to jumping around for a bit. Also most of the time, but especially in the first week we could count on Francken being our parents. Though I think most parents wouldn't support me chugging this many beers, being supplied in the first week with free toasties was a huge lifesaver, as I think most of us have not yet figured out how to feed ourselves.

In conclusion, the most important takeaway I want you as the reader to have, is that Francken will make you feel the most accepted in a family you didn't think you needed.

Francken Vrij!
In je hart
En in je ziel

Francken Vrij!
Voor elkaar
Supermooi

Francken Vrij!
Ennietvergetenzaterdaglayouten

For the bottom-up design of the future...

Physics

Chemistry

university of groningen / faculty of science and engineering

# Zernike Institute for Advanced Materials

## www.rug.nl/zernike

**You want to build the next generation of solar cells, starting from molecular building blocks? You want to change the world of computing by assembling revolutionary memory materials atom-by-atom? Or you want to develop materials preventing or curing disease? Then have a look at the Bachelor, Master and PhD programs related to and inspired by the Zernike Institute for Advanced Materials' research lines.**

We participate in programs of Bachelor and Master levels in the field of Physics and Chemistry. But, since it is our mission to train a new generation of researchers in cross-disciplinary approaches to research and equip them with the diverse skills required by modern science, we have initialized programs breaking the traditional boundaries between disciplines like e.g. the interdisciplinary Top Master program Nanoscience and the High Tech Systems and Materials Honours Master, which tackles real-life product development challenges in the same interdisciplinary fashion.

Additionally to the Bachelor and Master education, the Zernike Institute has the responsibility to train almost 200 PhD students to become independent, high level scientists. The main component is 'hands-on training', working side-by-side with the research staff of the institute.

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.