Theorist
The triology concludes

Meet the new board
Lear more about the new board of Francken

Inside View
Building blocks for a quantum internet

Francken Vrij
Future

Zernike Institute for Advanced Materials

You want to build the next generation of solar cells, starting from molecular building blocks? Or change the world of computing by crafting groundbreaking memory materials atom-by-atom? Maybe you want to use your talents and interests for learning how 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.

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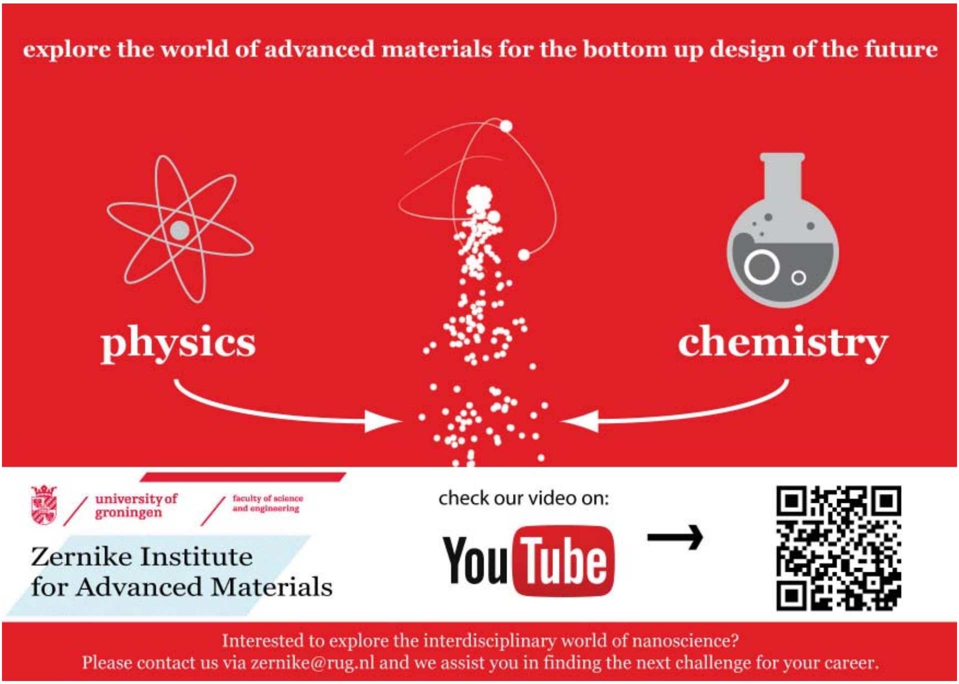

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Editorial

We're **finally past** the present, and are on to the **future**! As has become a the norm, this edition is also *a bit* later then we'd hoped for. My apologies for that. But I can assure you (and myself) that the editorial board is already busy with the next edition which *shouldn't* have any delays.

I probably don't have to tell you what the theme of this edition will be, since the very futuristic looking cover has probably given it away already. In this edition we'll also be exploring the future of Francken by introducing the thirty-sixth board of our association, enjoy!

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Chair’s Preface

By Chantal Rikse

Dear Francken members,
As Albert Einstein once said: “The important thing is not to stop questioning. Curiosity has its own reason for existing.” It’s good to ask questions. It’s a way to educate ourselves and better ourselves. And aren’t we all curious what the future may hold for us? At least I know I am. How long will it take until everything is back to normal and COVID-19 is contained? When will the Feringa Building finally be done and how many of us will still be studying at the university by then? When will it be possible to hang out at the Francken room again?

These questions sound a bit depressing, so let’s focus on the more positive things. In the upcoming year, Francken activities will be organised and we will see each other again. We have a new board and I have faith they will make the best of the upcoming academic year. As a board, they’re already revolutionary within our association, so let’s hope they will accomplish revolutionary things.

To conclude with another quote from the beloved Albert Einstein: “The future is an unknown, but a somewhat predictable unknown. To look to the future we must first look back upon the past. That is where the seeds of the future were planted. I never think of the future. It comes soon enough.”

News of the Association

By Sibren Wobben

Back when some of these activies took place, corona was still all the way in China, Joe Biden wasn't even elected as the democratic representative, and finding a candidate board was still a thing you could do tomorrow. Luckily, not everything has changed since Trump was probably already busy with suing people left right and center. Anyway, even though last acadamic year ended some time ago, that doesn't mean we didn't have a lot of fun and wonderful activies I'd like to tell you about.

Symosium theme annoucement social.
The eventual cancelation of our annual symposium didn't mean we couldn't enjoyed parts it! Way back at the start of January, the Sympcie presented their theme 'Cognitive Matters' during a karakterborrel at Gelkinge40. I vividly remember some of the worst darts I have ever witnessed in my life (perhaps I threw a couple of darts aswell, but who knows...). This part was suppose to be about the actual symposium, but it was not cancelled due to lack of ambition!

Half yearly general members assembly

Some time later we had to host our H-GMA. Usually the H-GMA isn't one of the fanciest meetings we have, but this one was special! It was the last GMA we had in real life, Jesse helped the board by being their *minuteman*, while Marten chaired the meeting. But most importantly, this became the evening at which during which Paul started his second year as chair of the association. Not only it was special, it was also the smoothest GMA we've had.

Freshman dinner

The freshmen never fail to disappoint you when it comes to ruining food. Even though their risotto was perhaps a bit undercooked, it was still a lovely evening with one of the highest sign-ups we had that year. Because of this there were enought people crack some jokes with (about the food) and make it an amazing event.

Digital symposium with Innovatiecluster Drachten

Personally this was of course my proudest event of the year. Together with the ICD we set-up a small online symposium where speakers from Philips, Stork, Resato, and Ventura systems presented their work and research at these companies. But there was also something much more important on the line! Namely, during their HighTech pubquiz, Bradley managed to win a ride in a Tesla.

International pubquiz

One can probably barely imagine it, but there was a time before corona as we can see in the picture to the right. The Intercie had prepared an amazing quiz for us, but the question round that still amazed me the most was the one in which they gave us sayings from their own country and we had to guess what they meant. From time to time it can already be difficult to understand people from England and therefore my group wasn't able to solve Tabitha's saying: "I'm going to spend a penny" (which appearently just means one is going to the toilet).

Francken friday lecture by Sytze Tirion

Of course we have also had our Francken Friday lectures. During one of our Friday lectures, Sytze told us about his master's project on *Spin-Orbit torques in 2D materials*. Nowadays there is a large demand for faster and dimensionally smaller electronics. During his presentation we have learned about a new and promising technique of controlled magnetization in magnetoresistive random access memomery (MRAM) by means of spin-orbit torques.

Melav covered in flags while hosting the Intercie pubquiz.

Apenkooien

On 11th March 2020, board *Nuclear* had its very last in-person activity. The honor of hosting this activity went over to the Sportcie who rented a room in Vinkhuizen where all members could run and jump around in a game of Apenkooien! For those who have never participated in such a game (since it's probably quite Dutch), it's basically tag with a lot of obsticals you can jump over. After that, we were looking forward to organising lots of activities, but sadly we weren't allowed to host these anymore. A sincere 'thank you' to all committees that helped us with organizing all of these amazing activities.

Meet the New Board

Melav Salih

Ayo! Due to my Kurdish cultural background, I have been described as annoyingly loud. Now, as president, I feel there is more way for my personality to be acceptable.

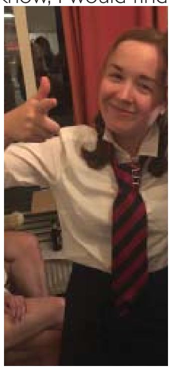
Like many students, I moved back in with my mother to drop some responsibilities, save on rent and focus on my thesis. Mind you, I've lost count of how many times I've packed and unpacked my bags - I don't think I have fully unpacked since I was 12. Hit me up if you need some professional packing/unpacking.

This also means less cycling for me! Hence, less cycling accidents. Fun fact: I have owned up to 12 different bikes in less than 3 years, until I lost count earlier this year. For the first time in years, I don't have a single bruise or injury. In fact, all my previous injuries have finally had time to recover!
Corona will not come in the way of improving our beloved association; if anything, we will use it to our advantage. Hope to see you all soon!

Tabitha Minett

Some of you may know me a little better as 'Tabz', or maybe just 'that British kid that isn't Duncan'. Anyway, as the designated English checker, it should come as no surprise to anyone that I am the secretary of T.F.V. 'Professor Francken' for the upcoming year.

Born and raised in London, I was excited to get away from the craziness and get settled in Groningen. Little did I know, I would find a different kind of crazy when I agreed to participate in the 2018 'Tour de Francken'. Thereafter, I came to love our wonderful association, and was soon enlisted in the Francken Vrij; that was the first time Sibren asked me to help with his English, and certainly not the last.



It's been harder than I expected to write about myself, especially as I've realised most things I do involve a lovely cold beverage, but here we go: I love everything yellow, I love to travel, and I roll burritos to earn money for my next holiday, so let me know if you're in need of the tastiest hangover cure.

Rosa de Graaff

Dear reader, I am happy to introduce myself as the new treasurer of our association. My name is Rosa and I have been active at Francken for 2 full years now. I have done multiple committees so far and have been present at also many borrels - in hindsight, maybe too many with respect to my study.

You might wonder whether I'm good with money or not. Well, if we talk about my own money, I'm very good in spending it… But with the money of the association, I promise to be a bit more careful, so that by the end of the year we can still provide free drinks and snacks which we all can enjoy. So this means a lot of spending, but also a lot of budgeting and saving.

Enough about money, I'm looking forward to the coming year. I hope as soon as possible the room can re-open again so we can all enjoy the vuige Francken coffee and some Dors after 4. But till then, stay safe! and hopefully see you soon elsewhere!

Emma Giovinazzo

Dear lovely members, my name is Emma and I am very proud to be the new commissioner of internal relations of our association. I am about to start my master's in Astronomy and I hope that this somehow means that I will have more time to drink, finally learn how to play klaverjas, and to spend many hours in the Francken room (when we're allowed back) - trying to convince everyone that speaking English is really nice and fun.

About three years ago, I left my sunny and beautiful hometown of Florence, Italy, to move to the gloomy and rainy Groningen, completely focused on my studies. A few months after that, I was added to the Sjaarscie groupchat, found out committees are fun, and I guess this is how I ended up here, writing this introduction.

Hope to see you all soon, maybe also in the Francken room at one point!

Hester Braaksma

As S.L.E.F.'s secretary, you may think I gained some writing skills during the past year, but I still struggled to write this introduction piece. Let's just start with the basics: I'm Hester Braaksma, just finished my second year of Applied Physics, am from the beautiful village of Scharsterbrug, my favourite cocktail is a Sex on the Beach, in the snackbar I always order a frikandel speciaal, and am the new commissioner of external relations of this wonderful association! I also wanted to list my hobbies, but lately with all the free time on my hands, I realised drinking and being hungover engaged a lot of my time in the past. Do I even have any hobbies? When I'm not behind my computer with the intention of study, but ending up buying shoes or a new outfit, I probably will be outside; I started running, but haven't reached the point that I enjoy it yet so wouldn't really call that a hobby, and I really like going for walks. Maybe I can call the most time consuming and my favourite thing to do my hobby: talking. So I will just end this introduction here and hope to see and, but more importantly, speak to you soon.

'Charm', the thirty-sixth board of T.F.V. 'Professor Francken'.

Life after Francken

By Kristel Staal

I am happy to tell you why I decided to become a mathematics teacher and how that combines with the crisis we are in at the moment, but since it has been at least a year since I set foot in the Francken room, let me introduce myself first:

My name is Kristel (most of you know me as Kristelijk or the one that says *foei*) and I finished the bachelor Mathematics and the master Education and communication. You may know me from several committees I was part of over the years, or the mathematics promo video on 'stoepkrijten'. Already over a year ago, I married fellow Franckenmember Jasper (I hear you thinking, "Which one?" I'm talking about jonkje van Stoal) and we moved to Zwolle together. For two years I have been a mathematics teacher at my very own high school.

Figure 1: Jasper & Kristel's wedding picture

If you had asked me at the beginning of my time in Groningen what I was going to be doing after I finished my studies, I would have said something along the lines of, "Something without having to interact with people, and definitely not a teacher." But as time passed, I realized that I started to really enjoy my time as a student assistant; being a mentor for first-year students and teaching tutorials for Linear Algebra 1.

Because of that I took an extra course called 'Education' and therefore had to do a small internship at a high school in Groningen. It opened my eyes and I decided to go for the master 'Education and Communication'.

For my master I had to do two internships: one for six months and one for a year. The first one was in Groningen, close to home, but I did the second internship in Zwolle at my former high school. They offered a grant, good supervision and high job prospects, so I took the opportunity. I quickly learned that teaching was rewarding, but also challenging and sometimes exhausting. Luckily, the energy that students can provide is contagious and the appreciation you get is amazing!

The past years I've had one or two classes of 'wiskunde C'. This type of mathematics is designed for students that do the C&M-profile (culture and society) and have had a lot of trouble with mathematics in the past. Mostly there are around ten students each year that start with 'wiskunde C' in vwo 4. I feel like one of my main goals, especially when teaching 'wiskunde C', is to get rid of their anxiety for mathematics. Such anxieties can block one's ability to calmly look at a math problem. My goal is to give them confidence in themselves and encourage them to keep trying. Everytime one of my students solves something that he or she would never have considered to be possible, it feels like such an accomplishment for both myself and them! This is one of the most rewarding things about being a teacher, in my opinion.

As you might have noticed, we are all in a bit of a crisis at the moment. The schools were shut in March and teachers had to quickly adapt to teaching from home. It was amazing to see how fast my colleagues and I learned and grew accustomed to this new way of teaching. Our timetable was adjusted to lessons of 45 minutes without breaks, resulting in the first lesson starting at 9:00 (as usual) and the last lesson ending at 13:30.

The key question became how to monitor the learning process of the students and how to help them accomplish the learning

goals of that particular paragraph.
Studies have shown that having an emotional connection with your students is one of the main things to make online teaching work. Luckily I had already put a lot of effort into that and tried to extend it by sending my students personal emails from time to time to ask them how they were, what it was like for them to study at home, and of course if they had more questions regarding mathematics. Although this was time-consuming, I believe this was extremely important for this process.

I constructed my lessons as follows: I started the lesson with a message on Google Classroom, in which I told my students what the paragraph was about, what the learning goals of today were and I added some hyperlinks to explanatory videos that I found online. Every student had to reply with the exercise they were starting with. The rest of the 45 minutes, they could ask questions in a reply on Classroom or send me an email with the particular question (if they didn't want others to see that they had a question). I answered the question often with a self-made video about the exercise, which I made with my phone in a phone holder (made for a car) attached to my window so that it was aimed at my whiteboard notebook. This made it possible for me to show them how to write things down and talk about it in the meantime. I posted the video's on Classroom such that everyone could watch it.

Figure 3: Finding ways to teach from home

In practice, it meant that some would watch and others didn't because they didn't need to. They were very happy with the videos, which made me realise how useful it can be, not only in times of online teaching, but also as an addition to regular teaching when things become normal again! This could help the students that have trouble keeping up in class. I will definitely continue making those videos once in a while (and re-use the ones I already made). In addition to the videos, they had to make a photo of one exercise a week, chosen by myself, on which I gave feedback. This helped me monitor the learning process of the students.

At the end of this term, just before the tests, I found a great way to use Google Meet to let them ask their last questions. I installed an app on my laptop and phone that enabled my laptop to recognize my phone as an extra webcam. This made it possible to explain questions, just like I did in my videos, with the addition that they could interrupt and ask questions in between. The interaction that was missing in the videos was spot on in the Meet-sessions. I wish I had known sooner that this was a possibility because I think that it would have been a great addition.

As good as it may sound, teaching is not nearly just about the mathematics in the current chapter and it is also not only about testing. This way of teaching lacks the freedom for teachers to be inspiring, to help the students find confidence in themselves, to teach the love of learning. This is already difficult in the normal way of teaching, let alone when teaching online. This can only be possible when we are face-to-face, seeing their expressions and feeling what the class needs.

At this moment, my students are still making their final tests to show what they have learned over the last months. I am very curious about their level of knowledge compared to the students of last year. Although I had a lot of fun teaching online and learned a lot, I can't wait to have all my students in front of me again!

Greg and Meg

By Bradley Spronk

Building blocks for a quantum internet

By Joop Hendriks

If one thing has changed our daily lives over the past 20 years, it must be the internet. At the start of the century, you still had to dial up for internet access. Cat videos were of course unheard of in those days due to slow internet, and YouTube did not even exist. But now, more than 98% of the Dutch population has access to the internet[1], almost anywhere and at any time. In times of social distancing and lockdowns, internet bring us together through Skype, Hangouts and Jackbox, still allowing for much needed social interaction. Staying home would for sure have been very different in the pre-internet age.

Much of those enormous streams of data are not meant to be shared, especially not if it concerns your medical information or a bank transfer. That's why data is often encrypted (i.e. transformed by some mathematical operation) when transmitted, so that an eavesdropper cannot make sense of it. The transmitting and receiving parties know which exact mathematical operation was used (they have key), and for as long as they are the only ones who have the key, they can securely send their data. However, there is no proof that the current algorithms are fundamentally secure. If somehow the eavesdropper finds a smart way to greatly increase his computer power (or even finds out how to use a quantum computer) to retrieve the key, he can possibly decipher the information.

How can we keep data transmission secure in the future? Is there a way to even make it fundamentally secure? The answer is yes. By making use of quantum mechanics, quan-

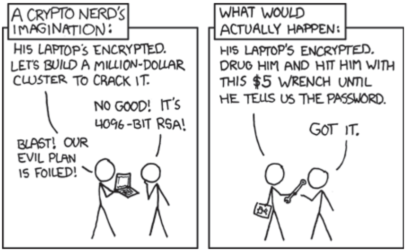


Figure 1: Information is only fundamentally secure in an information-theoretical sense. From:[7]

tum key distribution can make it possible. With quantum key distribution, an attempt to eavesdrop on the key is always detected, in which case the actual message will not be sent before distributing a new key and the information is kept safe. In case you are interested and want some background information, there are some nice earlier publications from our group[2,3,4]. For distributing quantum keys, you need to send quantum information from one end to the other. In more general terms, as you want to be able to do this with many different possible connections, you need a quantum internet! The most popular carriers for sending quantum information around this internet are few-photon pulses , as they can travel fast over large distances if they are guided in optical fibers. But even for the best fibers, the attenuation (photon-loss) length is on the order of 100 km, by far not enough if you want to send information across the ocean. The solution to this is to place quantum repeater boxes at fixed distances in the communication channel.

But 'repeating' a quantum state is tricky, as measuring such a state will immediately disturb the state of the photonic pulse (this is of course exactly why one cannot eavesdrop). A protocol called the DLCZ protocol describes how these boxes can be used to achieve communication over large distances by making use of atomic ensemble (i.e. a lot of individual atoms) and photons in a clever way[5].

The goal of the DLCZ protocol is to *entangle* two ensembles at the far ends of the communication channel. How we can get there and what it means is schematically illustrated in Figure 2. There are two atomic ensembles, I and J, with three relevant energy levels as drawn inside the squares representing the ensembles. In a simplified picture, we can assume that all atoms in the ensemble have the same three level energy structure where a single electron can occupy one of the levels, so we can prepare the ensembles such that the electrons from all atoms are in state $|g>$. The next step is to excite the ensembles to state $|e>$ with a short laser pulse such that on average less than one photon is emitted from a subsequent $|e>$ - $|s>$ transition, from either of the ensembles. We ensure that this requirement is fulfilled by using a sufficiently weak laser beam which is also slightly detuned, i.e. the driving laser photon energy is lower than the energy difference $|e>$ - $|g>$ by an amount Δ. This can lead to the emission of a photon with a frequency that

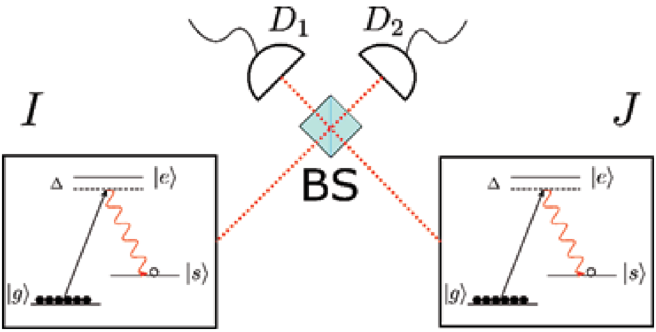


*Figure 2: Entanglement between two ensembles. Ensembles **I** and **J** are both illuminated with a weak laser, detuned by an energy Δ, such that on average less than one photon is emitted from either ensemble. The emitted photon pulses are combined in a beam splitter BS. Upon detection of a single photon in detectors D_1 or D_2, the two ensembles are in an entangled state. Figure adapted from[8].*

is lower than the laser frequency by the energy difference between $|g\rangle$ and $|s\rangle$. Next, the output pulses of both ensembles are filtered from the laser pulse and combined in a 50/50 beam splitter, where two single-photon detectors are positioned at the two output channels. If one of the detectors counts a photon (click!), you know that one ensemble contains a single excitation at level $|s\rangle$, but the beam splitter removed all information about from which of the ensembles it came from. This means the systems are now in a superposition of zero and one excitation, as you fundamentally cannot know where the photon came from. With the mapping $|0\rangle = |g\rangle$ (zero excitations in the ensemble) and $|1\rangle = |g\rangle$ (one excitation in the ensemble), this state can be written as (omitting a phase factor for simplicity):

$$\psi_{IJ} = \frac{1}{\sqrt{2}}(|1_I\rangle\,|0_J\rangle + (|0_I\rangle\,|1_J\rangle)) \qquad (1)$$

This is what is called an entangled state. It means that if you measure that the state of ensemble I is $|0\rangle$, the state of J becomes $|1\rangle$ at that same moment (as in the Einstein-Podolsky-Rosen paradox).

Let's assume that we now want to entangle two ensembles that are separated by several thousands of kilometers. That is by far too long if we want to do that in one go. The photon will be absorbed by the fiber before it reaches the beam splitter. But fortunately, we have enough quantum repeater boxes that we can put at fixed distances so that the communication channel from A to Z is now divided in a number of segments shorter than 100 km. We can do the entanglement trick for all segments first, as shown in Figure 3a. After that's done we can reduce the number of segments by halve by *entanglement swapping*, a process that is very similar to entangling two ensembles. Here, we look at two neighboring segments, each contains two entangled ensembles with a single excitation. In the swapping step, a strong laser pulse, the read pulse, will read out the state in two unentangled ensembles by efficiently converting the excitation to a photon pulse. The pulses are combined in a 50/50 beam splitter, and upon measuring one photon, we know there is still one excitation left in the system but due to the beam splitter it is again impossible to know where and the previously unentangled segments are now entangled (Fig. 3b). If you repeat the swapping operation step until there is only one very long entangled segment left, you have successfully entangled the qubits at A and Z (Figure 3c).

But there is a caveat: entangling two qubits is a probabilistic process, since it depends on detecting a single photon at one of the detectors while the probability of emitting a single photon must be smaller than one. If there are no photons detected, it means that the entanglement operation did not succeed. Now there are two options: you

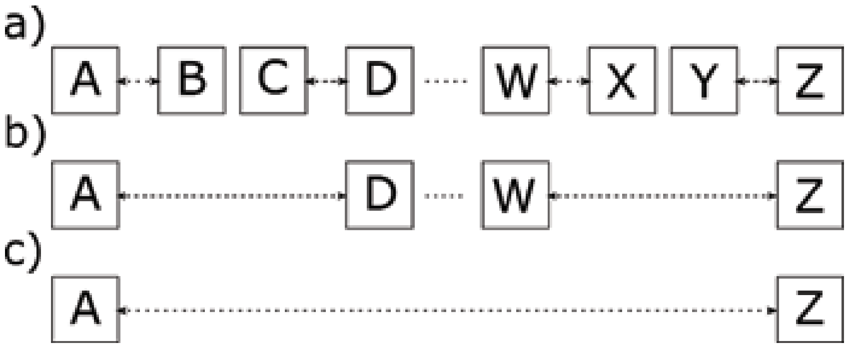


Figure 2: a) Entanglement over a large distance can be achieved by first entangling a number of short segments. The arrows indicate an entangled segment. b) after the first swapping step, the distance over which two ensembles are entangled doubles. c) The swapping step needs to be repeated until the ensembles at the far ends are entangled directly. Figure adapted from[8].

can either try to entangle all segments until by chance they are all successfully entangled successfully at the same time, or you try to store the entangled states and retry to the entangle the segments that weren't successful in the previous trial. The first option might work for a short distance but becomes very inefficient for longer distances. The second option is much better in that regard, but means that the ensembles must be able to keep the entangled state they're in stable for some time, i.e. they must serve as a quantum memory!

In the Physics of Quantum Devices group we are working, together with a European consortium of eight other research groups, on the realization of a quantum memory. In this project, called QuanTELCO[6], we are using silicon carbide (SiC) with transition metal impurities. SiC is a material which is widely used in the semiconductor industry, mature fabrication processes are readily available and a lot is already known about the optical and electronic properties of SiC with transition metal impurities. For this project, we are specifically interested in SiC with vanadium impurities, since these defects can absorb and generate single photons around 1300 nm. This wavelength is particularly interesting because it is right in the middle of the telecom O-band (1260 – 1360 nm), a range where the attenuation of the optical fiber very low and which makes it compatible with the current telecom technology and existing optical-fiber networks. This is also what makes this material unique, as competing materials do not directly emit at this wavelength and require tricks like frequency conversion before the photonic pulses can be sent across large distances.

However, many basic properties of vanadium defects in SiC are still unknown. In the coming years, we will study the physics of this interesting material and hopefully find answers on questions like: how do electron spins in the ensemble couple to photons? Why are the spin excitations disturbed by phonons and what are the processes behind it? Answers that will help us to better understand this material, which is much needed before a we can prepare a successful demonstration of a working SiC-based quantum memory and bring us one step closer to fundamentally safe communication.

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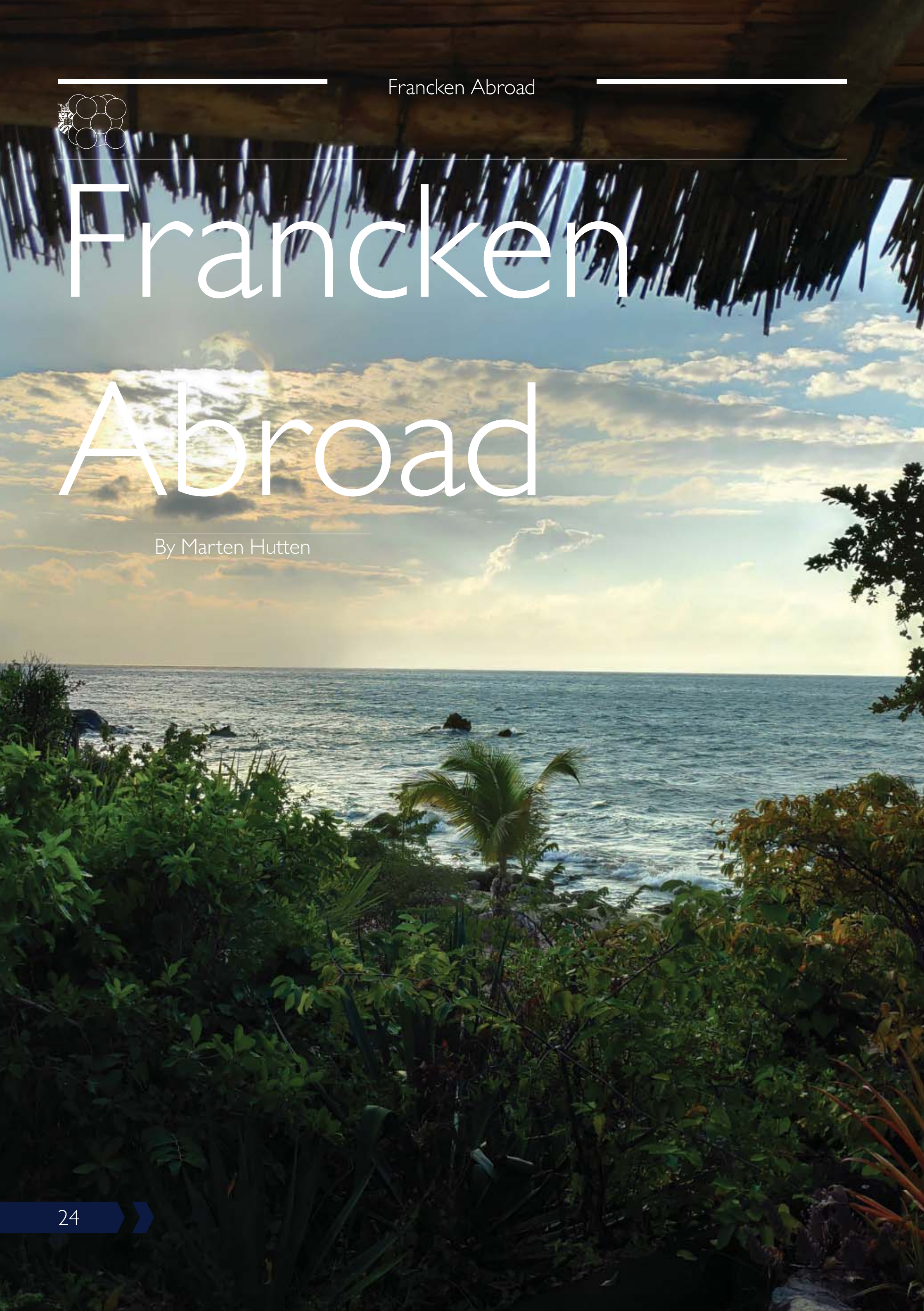


Francken Abroad

By Marten Hutten

Hello there! I didn't think I would ever write another piece for the Francken Vrij, so when I was approached by our former secretary (and my great-great-great-great-great-grand-kandi) I was initially quite surprised, but also very honored. Seeing as my time at Francken has been in the rear-view mirror for quite some time now, I have assumed that a short introduction is in order.

My name is Marten Hutten, former Astronomy- and SBP-student, former Francken secretary, former Francken furniture and accomplished TrackMania specialist. I graduated in 2017 and have since started working for drinking water company Vitens, first as a trainee and since September this year as a Data Scientist. You might have guessed it, but I fear this little story will involve very little physics, if any, but I have been assured that you, Francken Vrij-reader, are able to handle it.

One of the cool things about the Vitens-traineeship is that you get a lot of opportunities to do adventurous projects. Usually these projects are just here in the Netherlands, but Vitens also has a collaboration with (almost) all other Dutch drinking water companies, called VEI (Vitens-Evides International). In this collective effort, the companies work together with drinking water companies in another 19 countries, mainly in developing countries in Africa, Asia and South America. And because of this, I got the opportunity to go to one of their projects, in Mzuzu, Malawi.

If you don't know already, Malawi is one of the poorest countries in the world. Almost half the population live below the poverty threshold, and about 20% of the country does not have access to clean drinking water. Only in the bigger cities are there water mains, and even there, having a clean water tap is a luxury not everyone can afford. Regularly, a water tap is shared between multiple households. Generally though, Malawians get their water from natural sources such as rivers and streams. VEI works with the Northern Region Water Board (NRWB, the drinking water company in Mzuzu) to improve their business operations to allow more people to gain access to their network.

To put it mildly, the company is functioning sub-optimally. Not for lack of trying by the way, most employees are passionate about their work and want the best for all inhabitants of Mzuzu. But there is little coordination and overview, causing all sorts of mishaps and errors, unresolved leakages, meters left unread and connections left half-way done.

The team within this company that I was assigned to assist is the Non-Revenue Water (NRW) team. In short, this is the team that is responsible for reducing water losses, both physical losses (leakages) and administrative losses (from broken water meters, for example).

My job was to try and optimize some processes, as the person in charge of the team struggled to find their feet in a new function. Next to that, I was also consulting on a very ambitious project called a House-to-House survey. The NRWB had hired an external party to conduct this survey, which consisted of literally going from house to house in the whole Mzuzu area, and conducting an interview with the residents to update their customer database and to find all broken meters, lost connections and signs of tampering. The project was very interesting, because I was involved in deciding the questionnaire for the residents, while constantly trying to ensure that the external party held up to their part of the bargain and that the survey would actually take place.

It's not surprising they call Malawi the "Warm Heart of Africa", because the people really are very nice.

After some delay (Malawi really is a place where you can train your patience), the survey got underway, and teams of 50 mechanic-interviewer duo's went about the Mzuzu area to start their checks and interviews. I got the opportunity to tag along for a day to see the progress in action, and this also meant that I got to visit some actual Mzuzu residents. During my time there I was basically locked away either in the home office or office home, so it was very interesting but also very sobering to visit the houses of big families, which were sometimes little more than a small room with a roof and an outside shared water tap. Nevertheless, the inhabitants were very friendly and inviting and didn't skip a beat to offer me a chair, meaning they would sit on the floor. It's not surprising they call Malawi the "Warm Heart of Africa", because the people really are very nice. Though the hospitality of people was amazing to experience, I do have to admit that I've never been to a place where I've felt more 'privileged' and not sure if I will ever again.

Unfortunately, after only one week (out of a planned eight) of gathering data, reports of irregularities at a recent government election meant that civil tensions rose rapidly and more and more people were ta-

king to the streets to protest the outcome of the election. In case you are wondering: they found several voting ballots where the original vote had been erased with Tipp-Ex and changed to a more "government friendly" vote. After the first protests basically destroyed all glass windows on the main street, the survey slowly ground to a halt. This meant that I never got to see the survey completed because my time in the country came to an end shortly after.

Before I had to leave Malawi though, I did get the chance to experience some more of the country during the weekends. Unfortunately, there was not much to experience in Mzuzu. It is basically a little village (200.000+ residents but only one building higher than two stories, the building of the National Bank), where the biggest tourist attraction is, wait for it..., the shopping mall where you can buy your groceries. But, lake Malawi (after which the country is named) was nearby, so during my first weekend I traveled to the lake to stay at a lodge and enjoy the views and surroundings. Though getting there was quite a challenge, climbing over winding and unpaved roads for 4 hours, it was surely worth it!

My role in this project was to be handed over to a coworker, but as she arrived a few weeks before my departure we decided to travel as much of the country as we could together. With some 'interesting' travel experiences, ranging from standing in the back of a pickup as it's winding up the steepest road in Africa, to getting packed in a van with 20 people which is really only meant for 8 and having our luggage ejected as the tailgate flew open while going 80kph, we did get to visit the most beautiful parts of Malawi. We visited Livingstonia, where famous missionary David Livingstone finally settled down (i.e. finally found a place where his traveling companions didn't immediately die from malaria), to view the oddly Victorian village set atop a steep cliff overseeing lake Malawi. We also traveled to Liwonde National Park, en passant visiting the frankly boring capital Lilongwe, where we went on a boat safari to see lot's of hippo's, some crocodiles and some elephants really up close and personal. Maybe not the most over-the-top-amazing safari experience, but considering Malawi really hasn't unlocked all its tourism potential, it was just about as good as it gets.

To summarize the experiences: nice people, mediocre food, boring cities, bad roads and wonderful sights. Malawi is not the most accessible east African country, but if you can look past the practical and political issues, that are certainly not going away anytime soon, then you can find amazing places and inspiring people, who truly try to make the most of what they have.

Puzzle

By Arjen Kramer

Puzzles and games often involve a lot of predicting of the future. Whether that is considering the consequences of a move, or the effects of placing a digit. So, for this edition of the FranckenVrij, I have created a combination of a classic logic puzzle and a classic game, Sudoku and Chess. The letters represent the following chess pieces:

K - king
Q - queen
R, r - rook
B, b - bishop
N, n - knight
P - pawn

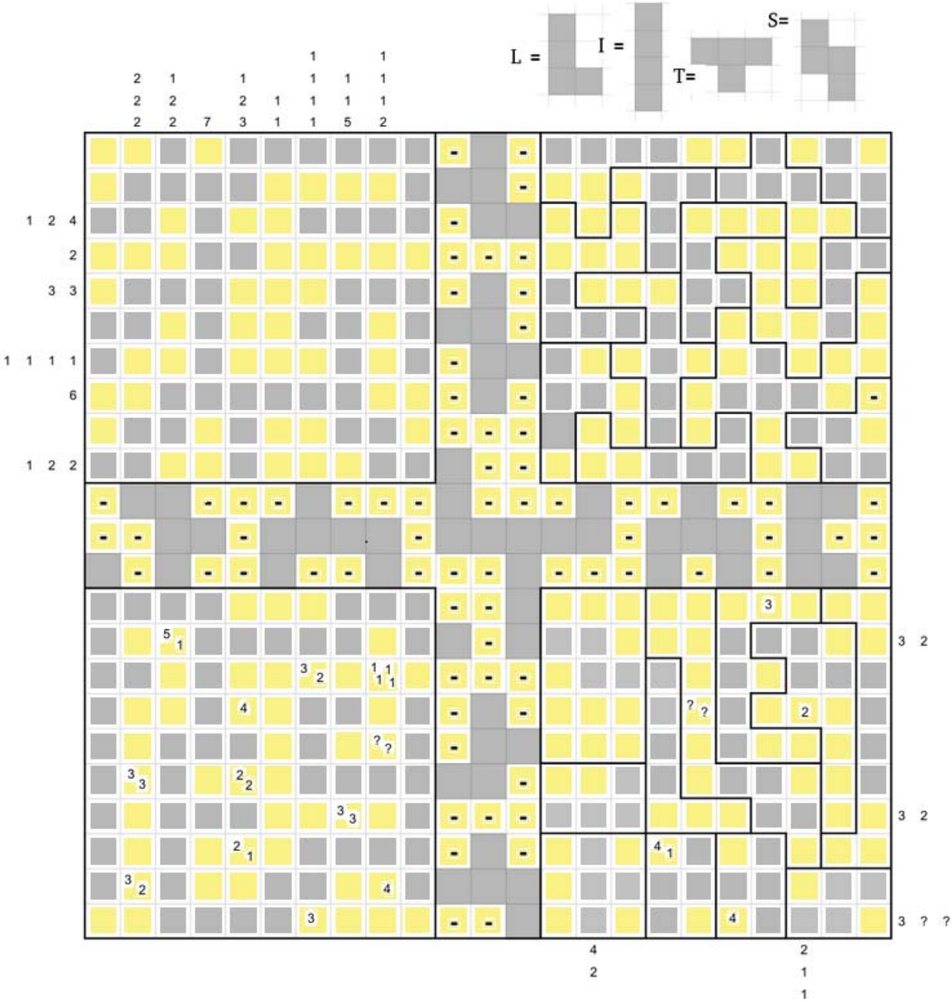
The goal is to place each piece in each row, column and 3x3 box using normal Sudoku rules. Also, the pieces are not allowed to be able to capture another instance of itself by a chess move, where each piece can move like it does in Chess, so a 'B' can not be on the same diagonal as another 'B'. The upper- and lowercase letters are considered different pieces, so an 'N' is allowed to see an 'n' by a knight move. Pawns move up through the grid and we don't consider things like promotions or capturing by en passant.

The sender of first correct solution will win the Chess Sudoku app made by Cracking the Cryptic for even more puzzle fun.

Puzzle:

				b				
				Q	K			
			r					
					n			B
N								
					R			
P								
R	N	B	Q	K	b	n	r	

Solution to edition 24.2:



Future

By Jelle Bor, MSc

To obtain a good picture about the future, time regarded as still to come, it is interesting to first review the history of our world shortly. Let me start by saying that the average life expectancy of a human being on our planet nowadays is 73 years (in the Netherlands it's 83 years). With respect to recorded history (started 3500 BC), the pyramids (~ 2500 BC) were older to the Romans (biggest empire around 100 AD) than the Romans are to us today. Let us take some big steps. 200,000 years ago, homo sapiens still lived together with at least five other human species. Six million years ago, the last common ancestors of the humans and chimpanzees still existed; this means that our close relative, the homo erectus, survived 10 times longer than we have expected. 65 million years ago, the age of the dinosaurs, which ruled the world over 165 million years, ended by an enormous asteroid hitting the earth. The first small animals dwelled our planet 600 million years ago. Life itself started 4.1 billion years ago, so for at least 3.5 billion years, the world was ruled by single cell organisms. 4.5 billion years ago, the Sun was formed from an imploding gas cloud, and 60 million years later the Earth was formed. With respect to the age of our Universe (13.8 billion years) and our own galaxy (13.3 billion years later), our solar system is pretty new. Comets and asteroids crashed frequently into the primordial Earth and probably provided most of the planet's water and perhaps much of the organic material necessary for life.

Organic molecules have been detected in comets, such as the Hale-Bopp, and researchers simulated cosmic crash landings by using a gas gun to fire metal projectiles at very high speeds into blocks of ice containing some of the same chemicals that make up comets. The shock wave and heat generated by the impact created molecules that formed amino acids, the building blocks of proteins. Yet the very same objects that gave this planet life could also destroy it, as happened with the dinosaurs.

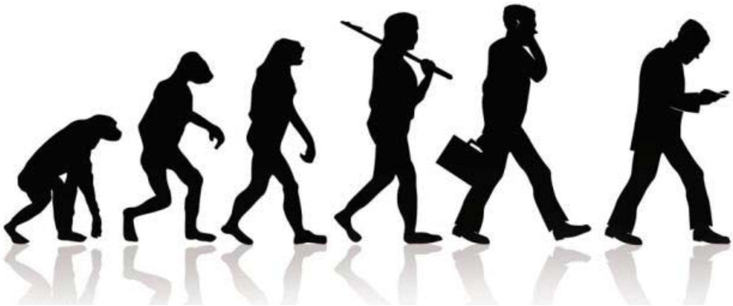


Figure 1: Evolution; where will we be in the future?

Astronomers have predicted that such objects large enough to cause global devastation will smash into the Earth about every 100 million years. Fortunately, people track near-Earth objects so that we can minimize such a disaster if we are close to one. In the future, in one billion years, the Sun will have become so hot to us (as it becomes a red giant) that life on Earth becomes impossible. This means that at some point humanity needs to explore other places to survive, if we are still around and we did not kill ourselves. When the Sun becomes a white dwarf, 4 billion years later, we can mark that as the end of the life of our solar system.

In the last Francken Vrij, we investigated the dark matter and energy problem that plagues present-day physics. However, it is these various dark energy models, causing the acceleration of the expansion of the Universe, that have led to the understanding of scenarios for the future of the Universe (many years after the death of our solar system).

We know that space is everywhere created equally. The space between galaxies expands, so they move apart. The space in galaxies also expands, but gravity is still strong enough to keep the galaxies' elements gravitationally bound. There is one exception interesting to notice for us as the tug of gravity that enabled the formation of the Milky Way has also put us on a collision course with our neighboring galaxy, Andromeda. This will happen in about 4 billion years. By that time, galaxies will be mostly empty space and so there will be almost no collisions between stars and planets. If we were able to observe the night sky by then, we would mostly see that the constellations would constantly change night by night.

In the Big Rip scenario, the expansion accelerates so fast that gravity cannot compensate for this effect anymore. First only large structures, like galaxies, are torn apart. Next, bodies like black holes, stars, and planets and dissolve into their components. At some point, space would expand faster than the speed of light, so no particle in the Universe can interact with any other particle anymore.

Another scenario is the heat death or Big Freeze. The difference with the Big Rip is that in a heat death, matter stays intact, but is converted to radiation over an incredibly long, but finite, period of time. The idea of heat death stems from the second law of thermodynamics, which states that entropy tends to increase in an isolated system. This implies that after sufficient time, the Universe will approach a state where all energy is evenly distributed. When this is complete, the Universe has reached its state of maximum entropy. After an incredibly long amount of time, it is however theoretically possible that a sudden entropy decrease happens as a result of quantum tunneling, leading possibly to a new Big Bang, to make the story more uplifting.

The next scenario is the most frighting one. The so-called "Big Slurp" says that the Universe is in a false-vacuum and that it could become a true vacuum at any moment. It has to do with the Higgs field that permeates all space to the Standard Model, much like an electromagnetic field: it varies in strength based upon its potential. Below some extremely high temperature, the field causes spontaneous symmetry breaking during interactions. The breaking of symmetry triggers the Higgs mechanism, causing the bosons it interacts with to gain mass. In the Standard Model, the Higgs mechanism refers specically to the generation of masses for the W+/-, and Z weak gauge bosons through electroweak symmetry breaking. A true vacuum exists so long as the Higgs field exists in its lowest energy state, in which case the false vacuum theory is irrelevant.

However, if the vacuum is not in its lowest energy state (a false vacuum), it could quantum tunnel into a lower energy state. This is called vacuum decay. This has the potential to fundamentally alter our Universe; in more audacious scenarios, even the various physical constants could have different values, severely affecting the foundations of matter, energy, and spacetime. So it is possible that all structures will be destroyed instantaneously, without any forewarning.
A vacuum decay will trigger surrounding Higgs particles to vacuum decay too, constructing ever growing destructive bubbles with enormous speeds. It can even be that it has already happened, but due to the hugeness and expanding of the Universe, it could take billions of years to reach us. However, this scenario is more a speculation, so you do not have to be to afraid of it.

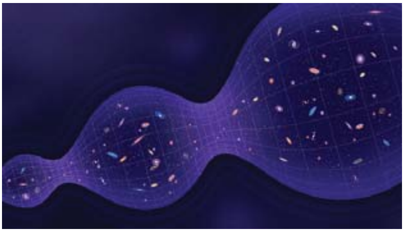


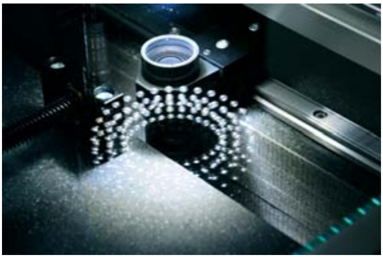
Figure 2: Prof. P. Steinhardt (an expert on inflation who has become one of its most prominent critics) and others have been developing a different story of how our universe came to be. In a cyclic universe, periods of expansion alternate with periods of contraction. The Universe has no beginning and no end. They hope to replicate the Universe that we see without the baggage that comes with a Big Bang (such as inflation).

The last scenario is presumably to most people the most romantic. In the Big Crunch, there is less dark energy than we think or it decreases over time, and one day gravity will be the dominating force in the Universe. The rate of expansion will slow down and stop. After that it reverses. Galaxies will be attracted to each other, merging as the Universe becomes smaller and smaller. The background radiation will rise.

However, the end result is unknown; a simple estimation would have all the matter and space-time in the Universe collapse into a dimensionless singularity back into how the Universe started with the Big Bang, but at these scales unknown quantum effects need to be considered.

And what about black holes, will they devour everything, such that we end with one super-massive mega black hole? Evidence suggests that this scenario is not likely, but it has not been ruled out as measurements are only available over a short period of time and could reverse in the future. This scenario allows the Big Bang to occur immediately after the Big Crunch of a preceding Universe. If this happens repeatedly, it creates a cyclic model, which is also known as an oscillatory Universe. This brings us to the the Big Bounce, a scientific model related to the beginning of the known Universe, where the Big Bang was the result of the collapse of a previous Universe. The theory states that this has happened a lot of times, so that the Universe goes through a finite stage of expansion and contraction.

As we will never see and experience the plausible destruction of the Universe, we should not worry to much about it. In the end, it would be nice to know what exactly will happen, but on the other hand we will just be here for a finite time, so you better enjoy yourself, it may all happen later than you think.



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