Decay of the Universe
The last theorist
by Remko Klein

An Inside View
Device Physics of
Complex Materials

The US of Francken
The last in a trilogy of
a year in America

Francken Vrij

Decay

Edition 21.3

Colophon

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Editorial

The theme of the last edition of this academic year is 'decay', an interesting phenomenon in Physics. Decay is also something that happens within our editorial board: Paul and Jasper will leave the committee after 5 and 3 years, respectively. We will miss their creativity during the process of editing the Francken Vrij, but we also hope to welcome some new members next year (and to be able to ask Jasper and Paul for some advice and help). The solution to the puzzle of last edition was Ludwig Wittgenstein. The winners have received an e-mail and can go to Steven to collect their prize. Enjoy reading this new Francken Vrij and have a nice summer!

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Chairman's Preface

By Anton Jansen

When physicists talk about decay, they most often mean radioactive decay. This is however not the only form of decay in nature. In fact, decay is an omnipresent phenomenon. For example, biological decay can be seen as the degeneration or decomposition of organic matter. While in spaceflight, orbital decay is the gradual decline of orbits due to atmospheric drag. Decay also has meaning in gamma sciences such as psychology and sociology. 'Decay theory' proposes that our memories fade due to the mere passage of time.

Decay seems like a force of nature, intricately connected to the second law of thermodynamics. Every living organism must expend energy to maintain homeostasis and prevent its own decay, and every element in the periodic table will eventually decay to iron-56 (assuming the proton is stable), the isotope with the highest per-nucleon binding energy. In a sense, even the universe itself is in a state of eternal decay, since the entropy of an isolated system can only increase.

The above description of decay makes it sound like a rather negative thing, but I think decay can also be seen as something positive. Sometimes for new things to happen, old things first need to fade or decay away. When you read this, our board year will have come to an end, and we will have made room for five new 'mooie gekken' that will run the association for the coming year. I am glad to already be able to look back at an awesome year, and I hope you are too. I wish you a happy reading of the new Francken Vrij!

Meet the New Board:

Kathinka Frieswijk

Dear Francken members, even though I've been called Francken furniture before, I'll (possibly, red.) officially be the chair of our beloved association by the time you read this. Some may know me as an editor of the Francken Vrij (*in je hart, en in je ziel…*), others may know my virtual counterpart Kathinka-bot. However, most people do not know that Jungle Book was loosely based on my childhood: I was raised by animals in the Emmerdennen. This might seem a bit strange to the attentive reader, since Jungle Book was published in 1894, but the case is that I also happen to be a time traveler. Why did I build a time machine? I thought it might come in handy. If you build it before you need it, there is no causal loop.

Currently, I am enrolled in the masters *Many Things*, among which Physics is the most prominent. My official title is "Kathleesi, Queen of the Great Grass in front of Nijenborgh 4, the Unfocused, Collector of Bachelors, and Mother of Small Animals and Plants", but a simple "Kat" will also suffice.

Anna Kenbeek

Hereby I would like to introduce myself, after trying my best to get rid of the nicknames 'Cora' and 'Klembeek', as Anna Kenbeek. I'm currently in my first year of physics and besides this I'm sometimes present at Francken, Dizkartes or the ice-skating association Tjas. Recently I decided to do something different next year: while my fellow freshmen will be trying to handle the chaos during the coming year by following lectures such as statistical physics, I hope to handle the chaos as the secretary and commissioner of education. This might be a difficult task, since after being part of the Buixie and Sjaarscie, I still *kan niets* or not a lot. Although I might have enough capabilities for being part of the 33rd board and keeping track of five uncontrolled board members and a whole bunch of other uncontrolled units. Anyway, these two committees also made me realize how nice Francken is and thus made me apply for a position as unmovable furniture in the Francken room. I look forward to making this an amazing time with Kathinka, Arjen, Su-Elle and Mark and organising the most fantastic activities. I hope to see you there!

Arjen Kramer

Hoi, my name is Arjen and I'm likely to be treasurer by the time you read this. Many of you may already know me, as I've been a regular presence in the Franckenroom for nearly four years now. There I can usually be found drinking lots of coffee and playing klaverjas, though I also make an effort to do more academically stimulating activities, such as making the puzzles in the metro, playing quizzes on Sporcle or trying to solve the AIVD-*kerstpuzzel*.

What some of you may not know, is that I was born and raised in Fryslân, and that my first study was at the TU Eindhoven. But I didn't feel at home and decided to go back north, to study physics at the RUG. Here I briefly shared a house with last year's praeses and I'm now living in the one and only "Franckenhuisje 1". I have already been part of multiple committees such as the Fraccie, Oefensescie and the Pienter committee. So I'm really excited for next year and expect that with the first five member board we will be able to make it exceptional.

Mark Redeman

It is well known that the s[ck]rip(t|t?c)ie fights for digital anarchy. However, since many of our members have recently obtained their degree it has become more and more difficult to actively pursue this objective. Luckily though we've recently started to automate many of our tasks so that we would have more time to spread the word of digital anarchy. This began with the development of our beloved s[ck]rip(t|t?c)ie chair, Kathinka-bot. Though effective at first, sadly some of the members of our association found it was quite easy to "kill" Kathinka-bot. As of this moment she has died approximately 635 times in the past year.

After many brainstorm sessions we finally found a solution to our problem: we should apply for the next board of T.F.V. 'Professor Francken' so that we can change Francken's digital presence from the inside out.

Thus next year I will join the board of 2017 - 2018 where I'll leave my **mark** as the commissioner of external relations. Though I might not yet be fully familiar with all re**mark**able subjects that Applied

Physics has to offer, I am confident that my passion for **mark**eting will be of good use for the association.

Su-Elle Kamps

Whilst writing this, I am seated in the Francken room next to the most beautiful Francken member, Petrus Arnoldus Josephus Wolff, also known as *lekkere* Pieter (according to his piece in the Francken Vrij of 2015). I recall a conversation we had on the previous candidate announcement borrel. Pieter asked repeatedly whether I would be the next board of Francken, to which I anxiously replied with a firm: 'No, of course not…'

I am, however, sharing this memory because I will move into the Francken room next year and become one with our association, merging my flesh and soul with Kathinkabot, until we evolve into an eternally lasting apparition, serving our association until the day we paradoxically die. All because becoming an active member has helped release the *mooie gek* within me and overcome my anxiety as a *sjaars* enough to apply for the board.

As you can see, I would rather write a story from which you can pick up some subtleties about me than go into depth about my personality. I have a feeling, however, that whoever is reading this will a) not care about my hobbies anyway, b) get to know me well enough next year and c) prefer the number of items to be three. Le'ah!

'Hè, Watt?', the thirty-third board of T.F.V. 'Professor Francken'

News of the Association

By Willeke Mulder

Before I assign my position as secretary of the board of T.F.V. 'Professor Francken' to my successor, I have the honour to write one *laatsten* News of the Association. Every member must have noticed that during this year there were many, maybe a bit too many, events. However these events bring back great memories. Below, there will be a short summary of some of these memories and some of the activities Francken has organised since the previous edition of the Franken Vrij.

High Tech Safari

On February 15, three busses left Zernike towards some of the companies connected to the Innovationcluster Drachten. The safari participants had to choose between three different routes visiting different companies of the cluster. The cluster had Route Sensoring & Big Data, Route Vision Intelligence and Route Robotics, where the Vision Intelligence was. The latter was by far the most popular route. After lunch we gathered at Philips to get a presentation and a lab tour. The day ended with a buffet dinner including all members of Innovationcluster Drachten.

Applied Physics Dinner

Last year the Applied Physics Dinner has proved to be a great success! Many staff members and students in the field of Applied Physics showed up, and finally there was an evening special dedicated to this field of research. The canteen of the Nijenborgh was transformed into a dining room where all applied physicists could enjoy a delicious three course dinner. We think we reached the goal of the dinner, which was

to improve the contact between all Applied Physicists of our faculty.

FYSICA

FYSICA is the annual physics conference of the Dutch Association for Physics (NNV). Each year the NNV organises FYSICA in cooperation with a Dutch university and this year Goningen was selected. Together with the FMF, T.F.V. 'Professor Francken' was responsible for a part of the organisation. In the end Francken member Robert van der Meer designed the whole corporate identity of FYSICA 2017. Highlights of the day were the talks given by Bart van Wees, the winner of the Spinoza prize, and Ben Feringa, the winner of the Noble prize for Chemistry.

Buixie

This year's foreign excursion went to Austria and Slovenia. Early in the morning of April 15, the participants left towards the Wombat Hostel in Vienna, this year not by van but by plane. In Vienna we first visited Ecoplus, a cluster of smaller companies. Tours were visiting the labs of AC2T, CEST and Fotec. Of course during the foreign excursion participants saw a lot more. We went to a planetarium, to a nuclear reactor, saw three different universities and visited AVL on their way to Ljubljana. We also went to see Slovenia's national meteorological service. Furthermore, we have visited the Postojna caves, the largest cave structure in Europe. It was a trip to remember.

Francken symposium

This year's Francken symposium had the very interesting theme "Rocket Science, Launching Physics into Space". The day started with a goodiebag stuffed to the rafters with nice goodies from cooperating

Highlights of the day where the talks given by Bart van Wees, winner of a Spinoza prize, and Ben Feringa, the winner of the Noble prize for Chemistry.

companies. There were talks from Dr. Ir. W. Sillekens (ESA), Prof. Dr. Ir. M. ter Brake (UT), Dr. Ir. G. de Lange (SRON) and Prof. Dr. S. Brandenburg (KVI) about rockets, space missions and space research. The talk from astronomy journalist Govert Schilling described various aspects of space science, concentrating on the exciting new results yielded by unmanned satellites and space telescopes and he did provide a look into the near future of space science.

Active Members Activity

Our active members form the beating heart of our association (metaphorically speaking). They are the beans to our cup of coffee, the carbon to our graphene and the hops to our Gebouw 13. The mere thought of a group of people that sacrifices their time and energy just to enrich our association feels like a warm embrace[1] to every board member. We therefore see it as a delight to thank them by organising an Active Members Activity especially for them. This year, this *merci à vous* took the form of a tour through Martinus Brewery. Our Brouwcie could learn a lot. This was followed by a dinner at the restaurant that feels most like home (and is most tolerant towards the exorbitantly loud singing of the *Franckenlied*): Pappa Joe. It was a great success.

1: Or cold beer, whichever you like best.

Beach Party

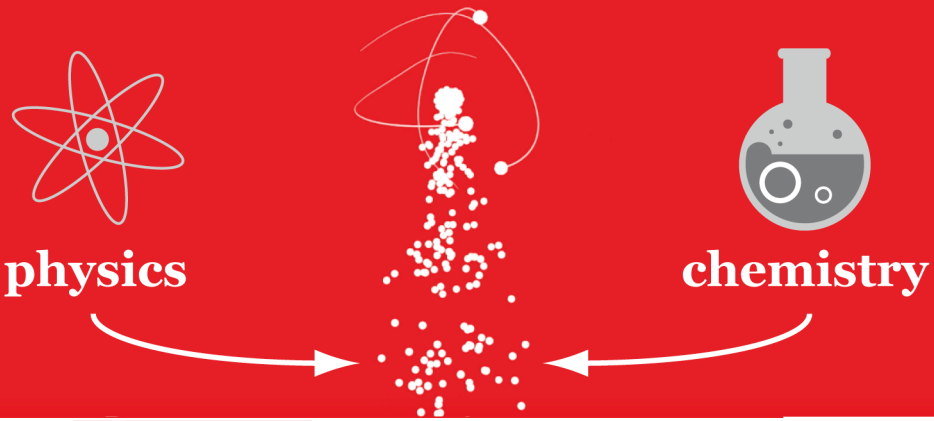
For the first time (at least this year), no less than three committees of Francken cooperated to organize an activity together. The Borrelcie, the Fraccie and the International committee got together, called themselves the B'Interaccie, and persuaded over 70 Francken members to visit their Beach Party at the Hoornse Plas in the south of Groningen. Even though unfortunately the blowing castle could not reach his saturated point[2], the BBQ with free food and drinks made the evening complete. The perfect weather also allowed us to take a swim in the lake.

2: The committee members could not get it up (that's what she said, red.).

Zernike Institute for Advanced Materials

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.

explore the world of advanced materials for the bottom up design of the future



university of groningen

faculty of mathematics and natural sciences

Zernike Institute for Advanced Materials

check our video on:

YouTube →

Interested to explore the interdisciplinary world of nanoscience?
Please contact us via zernike@rug.nl and we assist you in finding the next challenge for your career.

rijksuniversiteit groningen

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.

Our activities cover both 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 also have programs breaking the traditional boundaries between disciplines. We are very proud on our interdisciplinary Top Master program Nanoscience in this regard, which was rated the best Master program of the Netherlands the last four years in a row by national study guides. Next to this, we also offer 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 approximately 150 current 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.

Strategy Consultant

By Ir. Arjan van der Pal

And now for something completely different. Especially compared to the last contributions to Life After Francken, Strategy Consulting in the fast business world seems an odd one out. There seems to be no apparent link with science, whereas last contributors included proper formulas (Thijs Huijskes), referred to rigorous mathematics (Christiaan van der Kwaak), continued with a PhD and two post-docs (Bas Vlaming) or are working on micro filters (Gert Eising). Sorry, I'm letting appearance fool you. Working as a strategy consultant is not that far off from working as a physicist. Or as fun as physics. And I'll explain to you why, after I've introduced myself.

Back in September 2003 I first entered the Francken room, which was located across the hall from the current one and had a fume cupboard for midnight deep-frying. Within a few minutes, I was a new member (unlimited coffee for €5,- per annum, who wouldn't?). And after that things moved fast; Borrelcie within a week, renamed to Van de Peynacker within a month, Introcie after a few months and after 9 months I was treasurer of the 20th Board (there's an awesome picture on page 10 in FV20.2). After that a handful of committees followed and daily visits to the Francken room were only skipped for Buixies, an interna-

Working as a strategy consultant is not that far off from working as a physicist.

tional internship and the occasional hangover. In the meantime I became one of the six founding fathers of Technisch Fysisch Heeren Dispuut 'Dum Spiro Bibo'. In the Lustrum book to commemorate the 25th anniversary of the T.V.F. there's a contribution of our praeses e.t. H. Van Hoorn PhD explaining exactly nothing about what we're all about.

About 7.5 years after I entered the Francken room on that day in September 2003 my Life After Francken started. I became a Strategy Consultant at OC&C Strategy Consultants in Rotterdam. And today – six years later – I still am, though currently our office sails under the brand of Parthenon-EY. In the next part I'll try to explain what a Strategy Consultant is and does, how I came to decide to become one and why I after 6 years still enjoy it.

So what is Strategy Consulting? In short, we help CEOs (or some other big bosses) with critical strategic decisions they have to make. And, to identify what these critical decisions are. A CEO gets drowned in (conflicting) opinions every day. The sales manager wants X, while the operations manager asks for Y. Our added value as consultants is that we don't just say something based on opinion, but on clear quantitative facts. This means analysing our client's data and/or market reports or by simply making an educated estimate. A famous case for the latter is the question how much ping-pong balls fit in a Boeing 747. Which makes no sense at all: It is only worth transporting stuff by plane if their value density (€/m3) is high enough and ping-pong balls are at the wrong side of the scale. That's why microchips may come to Europe by plane, but ping-pong balls take a boat trip.


The Erasmus bridge from our roof

Let me illustrate what we do with a simple example. Say you run a couple of cookie factories and you want to increase profits. Where do you start? Fire employees and have others work harder? Speed up production by increasing oven temperature or would that negatively impact quality? Sell more cookies? But to whom? And what type? Can you increase your price a bit without losing customers? In our work we determine if these are all the ways to improve profits (a merger might help as well), quantify which are the biggest opportunities and what is needed to carry out the improvements: more or less staff, more or less factories, more or less - or different - products. We than combine the key output in a strategic/business plan for the next 3 to 5 years.

Why companies do not do or know this themselves you ask? Setting up plans like this is a craft that takes time to master and that is not always present at the company (I'll explain a bit more about the journey in this craftsmanship). Moreover, having an objective outsider may help identifying new ways of thinking or push through more controversial – but important – improvements.

So why did I become a Strategy Consultant and not – let's say – a PhD? After all, I found my Master Research very enjoyable, not in the last place because of the large amount of new insights that we created (I co-authored 8 articles). But that's exactly the crux: I enjoy gaining new understanding and do not really care whether that concerns friction of DLC-coated rubber or the fundamental economics of a hosting company. What I do not enjoy: detailing it all out until everything is good enough for a high-impact peer-review paper (remember I said co-authored?). And the level of detail you need in consulting is most of the time less than in science: as much as you need for you and the CEO to feel confident about making the right decision. And it's not that different: If you can quantitatively describe how an electron behaves in a magnetic field, you know how to build an old-fashioned TV. If you can quantitatively describe how a company reacts to a market and internal changes, you know how to improve profits. And this can be complex. We cannot always assume a company is a perfect sphere in vacuum. It may require an extensive model – including the weather forecast – to predict future demand.

We cannot always assume a company is a perfect sphere in vacuum.

I promised to explain why I enjoy what I do. Well, I like a fair bit of it. The intellectual challenge, the variety, working with inspiring and smart people (before my Life Af-

ter Francken I thought physicists were the smartest people in the world, though I ran into some decent Philosophers as well) and the fun stuff on the side.

First, the intellectual challenge and the variety. Our projects usually last 4-12 weeks, after which we need to better understand a business than the guy with 20+ years of experience running the show. It is true that I'm not 'wet behind the ears' any more, but working on project #31 for client #29 is different than growing old in the same company. I worked on the merger of two supermarkets, wrote the strategic plan of a public transport company and did work on catering, sauna's and flower breeding. It gives you a broader view, but not the detailed knowledge you'll need to develop in your next project on hosting or fire safety on oil rigs.

Another aspect that adds to the variety is the changing role you have on the project. Most of the time strategy consultants work in teams of 3 to 6. Currently, I am the Manager of a team, but you start out as Associate (c.3 years) after which you become a Consultant (c.2 years). In your first years you explore the toolkit of analytical instruments we use to substantiate the strategy: building market models, conducting customer interviews setting up and analysing surveys, or simply visiting a shop or location of our client to see how things work over there. You'll learn how to present your fin-

dings and eventually turn it into comprehensive story that can persuade our client. Once you're at that point you've built sufficient craftsmanship to be in the lead of a project. Note that this does not mean that you're just number crunching in your first year: you'll be right there in (internal) meeting where we discuss our emerging findings. Moreover, my role is called Manager, but I'm actually a trainer or coach as well: I need to make sure that the new generation is learning enough to take my role in a few years from now. In that sense a Strategy Consultant consists of two businesses that cannot live without one another: one advises our clients and another trains those who are capable to do so.

And I really like the colleagues and culture. They're great. I mean really great. They're the best. Tiny hands <\trump>. I know consultants are known to be a bit slick, but I praise the fact that students who meet me and my colleagues always find that we're more down to earth than they expected. Even if you reckon that we have some remarkable people walking around: a former professional ballroom dancer, a 2 *voor* 12 winner, a pub owner, a former advisor to a state secretary and member of the Dutch Australian Football Team with 3 Master degrees. But perhaps the most important: We get a fair share of these gems from Groningen. Cherry on the cake is the fun stuff we do with this young group of people (majority is 30-) such as going on winter sports together (boss pays), training abroad (Madrid/Chicago/…) including the so called social programme in the evening, rowing the Ringvaart Regatta together (100 km's), playing in the company band or Friday afternoon drinks on our roof terrace overlooking the Maas and Erasmus Bridge.

Downsides you ask? It's a tough job. I work longer hours than the average Dutchman

and I do not always know what time I can go home that day. I'd say it's a job for those who do not mind going the extra mile in exchange for the challenge and an opportunity to have influence on a high level. If this hard work leads to mental and physical decay? Nope, sickness and burn-out are a rarity. I guess the collaborative culture – of which the email thread 'Sharing is Caring' with all kinds of small advice is exemplary – helps.

Summarised, Life after Francken may be different, but it is exciting. Then again I'm writing this as last-minute as I studied for Statistical Physics 1 wearing a worn-out Francken *chillbroek* while drinking and already yearning for tomorrows Francken Alumni drinks.

N.B. Something related to this FV's theme: There's a free Zombie movie that is shot at LHC and by physics PhD's: *www.decayfilm.com*. Oh, and there's a 1080p HQ version for a Francken Film Night available. Just saying'

---------- Artikel 4. ----------
1. Leden van de vereniging kunnen zijn: ----------
   a. zij die Technische Natuurkunde studeren casu quo af- --
      gestudeerd zijn in technische natuurkunde aan de ------
      Rijksuniversiteit Groningen; ----------
   b. leden en oud-leden van de Vakgroep Technische Fysica. -

To answer Bas' question on page 10 in FV 20.2: Sorry Bas, you're not a member anymore. I myself, in fact, am, as only graduates in Applied Physics of the RuG can be.

Nano-instrumentation

By TNO

TNO innovates with impact. By bringing together a wide range of disciplines in two areas of expertise and thereby tackling societal challenges within five current themes. After graduating, Tom Constandse chose TNO mainly because of its traineeship program. He has found his ideal workplace in Bionanotechnology, his third traineeship track.

Our research group Nano-Instrumentation builds ultra clean equipment that functions in demanding environments, mainly for the semiconductor market. This involves clean design, contamination analyses and mitigation. A major activity is the development of equipment for 'Next Generation Lithography' machines (wafersteppers and scanners). Including a.o. the design and realization of systems and sensors for the UV and visible wavelength with nanometer mechanical stability and with strong requirements in view of environmental conditions (vacuum, radiation, molecular and particle contamination). This research group also develops fabrication processes for nanostructures and applies this in component development for the new field of Quantum Computing.

Bionanotechnology

Tom is now program manager Bionanotechnology at this research group. "If we want to explain what happens in the world around us, we have a tendency to view it through the prism of one specific science.

TNO innovation for life

As an interdisciplinary academic, though, I think we've reached the point where that's just not enough. Certainly on the molecular and nanometric scale. The way we look at the world needs to change fundamentally. Instead of a vision with chemistry, physics and biology as distinct disciplines, we need to examine all aspects of molecules together. Biological challenges can be solved using knowledge from physics. And vice versa. Nature has created an ingenious means of data storage in the form of DNA and information scientists should make the most of it. Nano helping bio, bio helping nano."

Physics at TNO

For TNO innovation means demonstrating how significant knowledge is for society. Working at TNO means working in teams on inspiring assignments for multinationals, small and medium-sized enterprises and government. You contribute directly to innovation and the ongoing development and application of knowledge. The assignments range from contract research to consultancy, from policy studies to testing. Physicists at TNO work on applied research. They generate solutions to real societal problems, by using 3D nanotechnology and quantum computing. There is a variety of technical challenges in many areas of interest: fundamental research, applied research and engineering. The results of their research are used by government and corporations.

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United States

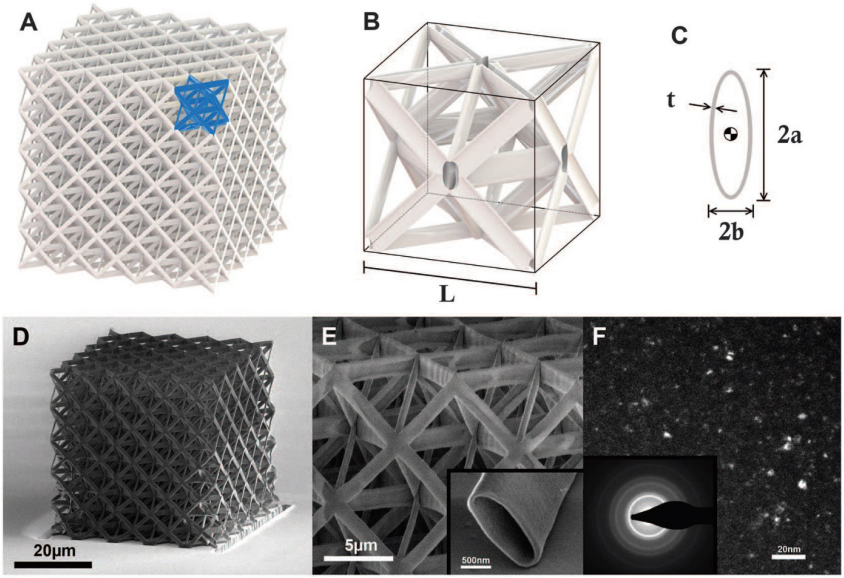
Of Francken

Is it possible to program the properties of a material?

By Rob Jagt

All good things eventually must come to an end. For a period of 9 months I did research at the California Institute of Technology (Caltech), a super awesome experience. After my time in the United States it is time to talk about the inevitable: what did I exactly do on the other side of the globe? In my last episode: how to use the concept of architecture to design materials with unprecedented properties.

Many materials found in nature exhibit structure on more than one length scale. This structural hierarchy can play a major part in determining the bulk material properties. Take for example the wings of a butterfly (see also figure 1). These wings are made out of polysaccharide chitin. However the optical properties cannot be explained with knowledge of polysaccharide chitin and its specific microstructure. Instead the optical properties are mostly determined by the hierarchy or gyroid structure of the material at a larger scale. Just like a periodic electrostatic potential causes a material to be a semi-conductor, so does a periodic dielectric constant gives rise to a photonic band gap and the beautiful colors of a butterfly wing. This is an example of an photonic crystal and the photonic properties are determined by the architecture of the material.



This concept of hierarchy is something which can be found in many different bio materials and engineering. Hard biomaterials found in nature such as mollusk shells, nacre and beaks obtain their resilience and damage tolerance due to the hierarchical arrangements in their design. Similarly within engineered structures, like the Eiffel Tower, the introduction of architectural elements provides a more efficient way to distribute the load-bearing capability when compared with the monolithic counterpart. Due to advances in fabrication processes it is now possible to create nanoarchitected structural metamaterials which extend this concept of architecture to the micro- and nanometer length scales. An example of an nano architected material can be seen here above. At these reduced dimensions extrinsic classical size effects can decouple coupled material properties, which creates the possibility to make metamaterials with amplified properties.

To write these type of materials a two photon lithography process is used, which is written in a special femto second pulsed laser system. The focal point of the laser is scanned through a negative photoresist and programmed to follow a certain path. This creates the possibility to make arbitrary complex structures in three dimensional space. Only where the intensity of the la-

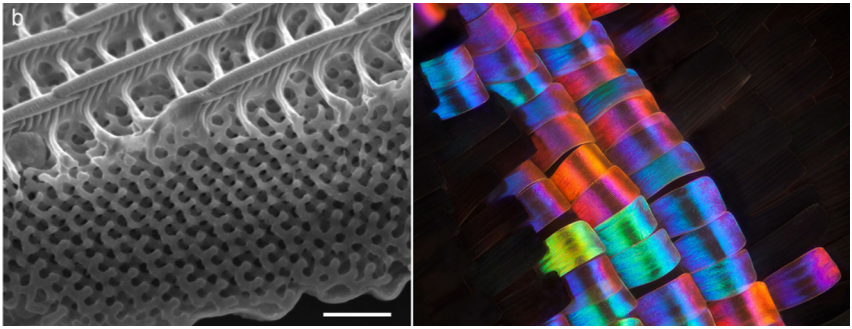


Figure 1. Scanning electron (left) and optical (right) microscope image of a butterfly wing (Callophrys rubi). The scale bar indicates 1 micro meter.

ser is sufficient the monomer is cross linked and hardens the material within the voxel. This is because the process of cross linking is a two photon process. Because of this it is possible to write features with up to 100 nm resolution even though you are using 780 nm light to write the structure. The polymer scaffold is then coated with a material using a thin film deposition technique (atomic layer deposition , chemical vapor deposition, sputtering, …). Subsequently the structure is opened up using a focused ion beam and the inside polymer is etched away using oxygen plasma.

The objective of my research was to design, fabricate and characterize nanoarchitected materials with simultaneously low density and thermal conductivity and yet high stiffness. Within thin films it is known that the thermal conductivity decreases when the thickness of the film is comparable to the mean free path of the phonons, which transport the heat. Since our nanotruss basically is a two dimensional film wrapped around a three dimensional architecture we can use this size effect to decrease the thermal conductivity. Eventually the thermal conductivity is measured using a four point probe within an experimental setup called 3 omega. Some of the final results and how they compare with other material classes are depicted in figure 3.

Since the architecture is something which is controlled by the design you coded this gives you great controllability of the final properties of your material. This has the potential to shift the material science paradigm from structure » processing » properties to property » architecture » fabrication and let you actually program the material properties you want to have for your application.

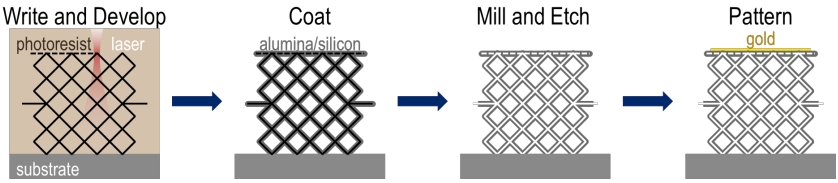
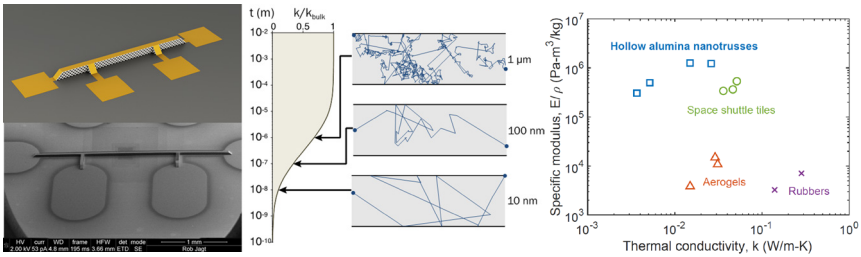


Figure 2.The fabrication process: Write the nanotruss, coat it using a thin film deposition technique, hollow it out and deposit gold on top of the structure.

To conclude, for all the Francken members who still have to do their MSc thesis or industrial internship, I can highly recommend it to do it abroad at a cool place. Of course it is a lot of work to arrange, but eventually it is worth the experience you get back for it. When I finish writing my thesis I will officially be graduated for both my masters and will continue to do a PhD in material science at Cambridge! With that I would like to thank everyone for the nice time at Francken and hopefully our paths will cross again in the future.

Figure 3. Left: design and fabrication result of the used device to measure the thermal conductivity. Right: The specific modulus over the density as a function of the thermal conductivity for different materials.



Final chapter:
Flashbacks and memories

By Joran Böhmer

By the time I wrote this my time in the States had already passed. To conclude this United States trilogy I'll bring up a few memories and stories to share. A lot of you have shown a great deal of interest in my time out there and asked me some interesting questions that I'll try to answer for you here as well.

When my plane landed back in the Netherlands, the first thing I did was run to a sink to chug some fresh water. It's not that Bostonian tap water isn't drinkable, but it's just disgusting. I would only drink it if I was completely dehydrated. The quality of Dutch tap water immediately felt like home. The second item on my list I was eager to get was just a loaf of bread including a choice of the wide selection of meats and cheeses that go with it. That's when I thought of the expression of 'living on bread and water'. It's supposed to be a prisoner's meal, while it is actually quite a premium meal if you compare it to the bread and water in Boston. I guess it would also be too expensive to feed prisoners loafs of bread in Boston since half a loaf already costs $4.50. Still, living on bread and water would be a way bigger punishment in the US.

Shortly after everything was back to normal again. For many things, among which


Boston skyline

When someone at MIT would say: "Let's meet at that weird building.", this is that building.

water and bread, this was great. Of course there are some cultural differences hidden in the sentence that 'everything was back to normal'. Because America is a country of extremes, a lot of things that we consider extreme are considered normal in America. This might be better to comprehend with an example of beer. In the American language they don't even have a word for what we call 'special' beers and it's not because they don't have them, but because special beers are normal to Americans. This is why the US is such an interesting place to live. There are things that I miss, regardless of whether these things are better in the Netherlands. They reminded me that I was actually in quite a special place.

Take for example the many weird jobs people can have due to America fighting the unemployment. Every time that I'd get groceries at a supermarket, there would be someone bagging my groceries although I'd already carry a backpack. If you'd go to an even bigger place like Walmart, they'd include a person having the job to say 'hello' to you at the entrance. And these people are happy to do their jobs, because at least they have a job. You see these kind of jobs everywhere. Every now and then I'd see policemen standing near some step or hose for a couple of hours, warning peo-

ple not to trip over it when walking the sidewalk. The reason for this job is probably different, because I'm sure you can sue some company or government for a big amount of money if you would actually trip over the step or hose that isn't supposed to be there. Just seeing people do these kind

'DEFENCE!'

of jobs can make my day. What I also like about America is that many normal buildings or facilities turned out to be the biggest I've ever seen. This is how little things can turn out to be quite an experience. In the beginning I'd already feel like this when going to a supermarket for example. What I also miss is the service you normally get at restaurants and any other place where they expect a tip from you. You'll be served a glass of water before you can even ask for it and if you're drinking coffee they'll refill it for you without you even noticing. Usually they'll need to wait for you to make up your order instead of you waiting for them to take an order.

But to truly get that American feeling you need to visit a sports game or comedy show. Let's start with the sports games. I've seen two live games: one basketball game and one ice hockey game. Every game starts of course with someone singing the national anthem. This person is often a veteran or other "freedom" related person. Everyone in the arena will stand up, pressing their hand against their chest while a waving American flag will be displayed on the screens surrounding the arena. This entire thing will be repeated during half time. If this doesn't grind your American gears, you'll have cheerleaders accompanying the basketball and an amazing light show on ice with the ice hockey game. At random moments during the game the spectators

NBA game at the Boston Celtics

will chant 'DEFENCE!' and this is about as smart as the commentary will get. With the ice hockey games they'll step it up a notch by throwing in a few fist fights and the crowd will go wild, American-style wild. I met the same type of people in the audience of a comedy show of Jim Jefferies. The Americans don't behave very differently during a sports game or comedy show apparently, but I'll get back to that. For the people that don't know Jim Jefferies: he's kind of a controversial comedian in America, because of his normal view on gun control for example. However, he presents it like no other. The show's appearance is a bit like a walk-in dinner show. People walk in and out to get beer and the front rows are sets of tables where people sit around. It didn't take long before someone had to be taken out of the audience by guards, because she couldn't keep her mouth shut. After she made a comment on Jim's shoes, she thought it was okay to have a lengthy discussion with the man. A while later, Jim made a joke about veterans and that was the point where a few people couldn't take it anymore. After this the audience turned more into that of a sports game than of a comedy show and the show had to be delayed a little. No problem for my girlfriend and me as we were enjoying the scenery.

Still, amongst all the great things I wouldn't want to live in the US. It could be fun for a couple of years, but on the long run I look at how the country is organised and how this influences everyday life. I think it's safe to say that the Netherlands just wins on almost every aspect of it. I'm not just saying this because of the brainless baboon running the country. The country does need some change, although it shouldn't be in the backwards direction. With this the stories have come to an end. There are still many more to be told, but for those you'll have to ask me.

Helping young talent grow

By TMC

The most important lessons not only broaden your mind – they turn you into a different person. At least, that's what happened to Izan Castro Molina, former TMC Employeneur. 'I feel like a different guy,' Izan says. 'It seems like a lifetime has passed since I started working at TMC Eindhoven – and that was less than two years ago.'

Izan Castro Molina (1990) grew up and studied in Galicia, North-West Spain. His studies in applied physics took him to Madrid, and then to Groningen, and then on to Eindhoven, where he took his internship

at Philips. He heard about TMC through several colleagues. 'They told me about the Employeenership Model, and I also learned about TMC's special programs, aimed at a new generation of engineers. It didn't take long for me to start thinking that TMC could be the perfect place to start my career.'

A couple of months later, after a well-deserved break in Spain, Izan returned to The Netherlands. He visited a job fair, because he knew TMC would be represented there. Izan handed his CV to account manager Bram Thelen. Soon, he was selected for TMC's Pitch Session, a new selection process for candidates with high potential. Along with around eight other people, Izan was invited to give a talk about his career, his life, and his expectations.

Izan must have done something right, because he was invited to join TMC immediately. 'Two days later,' Izan recalls, 'I already had a project.'

At the end of April 2015, he started at ASML Eindhoven as a design engineer. As a member of the Defectivity Performance Group, Izan became responsible for keeping ASML's scanners clean from contamination. His team works to develop tools and software that detect and prevent the presence of nano-sized particles in ASML scanners.

As of January this year, Izan became a full-time employee of ASML. He also became part of ASML's Technical Talent Program, a two-year program for promising newcomers. 'The idea is to boost the careers of young engineers like me, to accelerate our development through extra training and coaching sessions.'

It's easy to hear the enthusiasm in Izan's voice when he talks about his current work. He also looks back fondly at his time at TMC: 'It was my first real work experience. I learned so many new things. Not just from a technical perspective, but also on a more personal level. TMC is great at helping engineers develop soft skills: communication, planning, working with stakeholders. Every month or so my personal coach and I came together to discuss the work and my goals, and to find answers to my most important questions. I'm sure I'll benefit from those chats and lessons for the rest of my career.'

Explore Quantum Phases on a 2D Flatland

By prof. dr. J. Ye

In the broad material world that fascinated me ever since my undergraduate project, nothing is more striking than graphene for the past two decades. It is hard to recall all my feelings and thoughts when graphene was first reported in 2004. But without touching anything deep in physics, the most amazing point of graphene, at least to me, is how simple it is! Or in another words, it is really accessible. Indeed, borrow one standard graphite substrate used for calibrating atomic force microscope from your neighboring lab and buy one roll of scotch tape from a stationary store nearby; nothing more, you are already a graphene researcher! When the chance is so open for everyone, especially for poor young researchers, graphene then turns to be a wonderland that attracts us to go rock-'n-roll.

There are also multiple more scientific reasons for the surge of graphene. Physical, two-dimensional (2D) systems like graphene are very special: they have almost all properties in three dimensions but could be described rigorously because many important physical models can be solved analytically only in 2D. Technically, it was really lucky to encounter graphene because it is metallic and chemically inert. The great ad-

vantage to work with a piece of metal is that you don't need to worry about making good electrical contacts. The quality of contacts on graphene is not so different from that made by wiring up the lamp of your apartment. Therefore, at least, part of the reason for its popularity is because making graphene devices is dummy proof.

How to make devices that control quantum states? The twist was to learn something from a totally different field.

Discovery of graphene opens up the vision of a flatland where the materials are atomically thin so that the world is flat without height. Afterwards, it was not long before the researchers realized that this flatland is much broader because hundreds of other materials could also be peeled into atomically thin sheets just like graphene. From 2007 onwards, I started my exploration. The thing that attracts me most is that this flatland also hosts rich resources of quantum phases such as superconductivity, charge density wave, and ferromagnetism (proposed decades ago, but reported recently, actually only a few days before I wrote this piece).

This was my motivation initiated in Japan, which I continued in the University of Groningen for the past three years. To learn from graphene, the most straightforward idea is to try the same kind of study of making transistor devices on other 2D atomic layers to realize controllable quantum phase. As field effect transistors can control the conductivity of a semiconductor by using electric field, it has been proposed that quantum states in this flatland have great potential to enrich the functionality of transistors. We would like to see a switching superconductor circuit that costs no energy, generates entangled photons for sending information, and induces ferromagnetism for better data storage. But to realize all these dreams, the prerequisite is to establish control! There is no good switch in the quantum world because most quantum phases are willing to change only if substantial change of carriers could be brought into the system, which is really hard to realize by normal transistors.

How to make devices that control quantum states? The twist was to learn something from a totally different field. I've chosen the ionic transport. Surprisingly, the concept commonly regarded to be in the realm of fluidic systems of electrochemistry or biology actually lies in the heart of microelectronics, dating back to the invention of the field effect transistor (FET), the fundamental building block of modern electronic devices. As illustrated in the Nobel lectures for the invention of FET (Fig. 1) [1], J. Bardeen – who has twice won the Nobel Prize in physics for FET and BSC theory of superconductivity (interestingly both are

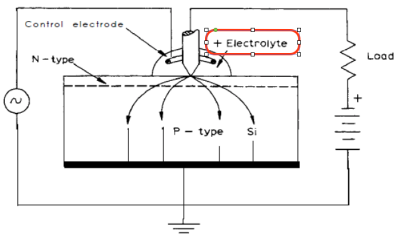


Figure 1. Schematic illustration of the first transistor made in Bell labs by J. Bardeen and co-workers.

key concepts in my research here) – described the attempt to create field effect in a prototype device based on the ion movement in an electrolyte: a polymer and ion mixture now widely used in ionic capacitors and batteries. For decades, this initial attempt was hardly mentioned, since later on more stable and responsive devices were made by all solid-state materials.

The solid state FET has been dominant for decades. But when the very first prototypes of field effect transistors were designed, more than half a century ago, the devices were in fact based on moving ions dissolved in a polymer. To use this idea again, there is a bit of a conceptual barrier that contains not only the patience to look into the warehouse of old garget, but also the courage to work on something that you are not so good at. For instance, as a device physicist, I have to learn electrochemistry to a modification of a classical three terminal FET device as shown in Fig. 2a [2]. The key change, instead of gating by solid-state dielectrics, utilizes the interface formed between a liquid ionic conductor and an active semiconductor channel (Fig. 2b). Under an electric field generated by voltage bias, the ion movement in the ionic conductor and the carrier movement in the electronic conductor stabilize at the interface, forming spatially separated charge layers called electric double layers (EDL). Closely resembling a capacitor structure, the EDL capacitor has orders of magnitude larger capacitance than the conventional solid-state counterpart due to the narrow distance (~1 nm) between opposite charges. This device structure enables FETs to access broad range of carrier densities, where changes in the materials properties extend far beyond the change of conductivity and is characterized as drastic changes in electronic properties showing superconductivity, ferromagnetism, multiferroics, etc. after reaching quantum phase transitions (Fig. 2c).

In this rapidly-growing field, control of quantum phases has been demonstrated as inducing superconductivities in $SrTiO_3$, ZrNCl, $KTaO_3$, $YBa_2Cu_3O_{7-x}$, and MoS_2, switching Mott transitions in oxide like $NdNiO_3$, manganites, $SmCO_3$ and VO_2, and tuning of magnetism in Mn-doped GaAs, ultra-thin Co layers, and in a magnetic-doped topological insulator, $(Mn_xBi_{1-x})_2(Te_ySe_{1-y})_3$.

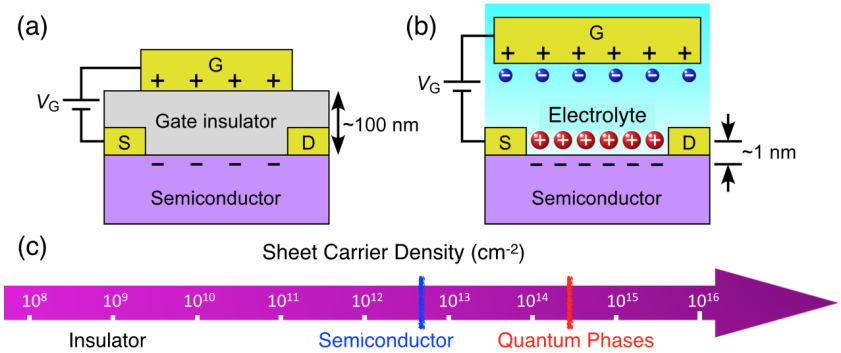


Figure 2. Schematic structures of two FETs and their range of working carrier densities. Panel (a) and (b) show a conventional and an ion-gated FET, respectively. (c) The tunable carrier density ranges of conventional FET and ion-gated transistors are marked with blue and red lines, respectively.

All these previous results represent initial steps to prove the concepts. And the flat quantum land is still at a stage of exploration. Honestly, we still know very little! But the intuition tells that present techniques might be the key to enter the regime of controlling quantum states with exciting choices to combine different quantum states like superconductivity, entanglement of photons or magnetism into future devices. It is really difficult to predict what more will be found in this flatland, what kind of phenomena we will bump into, and where the boundaries to overcome will be.

So far the land seems to be totally flat like the Netherlands. The exploration keeps rolling on.

References

[1] J Bardeen, Nobel Lecture of 1956: Semiconductor Research Leading to the Point Contact Transistor http://www.nobelprize.org/nobel_prizes/physics/laureates/1956/bardeen-lecture.html.

[2] S. M. Sze and K. K. Ng, Physics of Semiconductor Devices (John Wiley & Sons, 2006).

Decay of the Universe

By Remko Klein

Before going into the actual topic of this piece, let me start off with informing you that this will be my last contribution as the Theoreet. Hopefully, in these past two years I have been able to humor at least some of you by giving a glimpse of the sometimes quite preposterous ideas – don't blame the theorist, blame the universe – die-hard theoreticians work on. Regardless, I sincerely hope that next year there will be a new Theoreet who will continue to valiantly defend the honor of the theorists here in the lions den!

Anyway, let's get going. Recently I had to give a talk to high school students whom were visiting the university. Well actually, my supervisor was supposed to give the talk but he had to cancel last minute. Lo and behold, that of course meant I had to act as a last minute stand in; surely other PhD students can relate. In any case, to amuse the students I discussed two topics that I guess everyone finds quite fascinating (and rightly so). The first being the possible beginning of the universe and the second the possible end of it all. In particular I discussed some possible doomsday scenarios that might await us.

Amongst these are the Big Crunch (which entails that the whole universe will eventually contract into a singular point and sort of seize to exist) and the Big Rip (which entails that the universe will expand faster and faster eventually ripping all structure, including us, apart). In fact, by far most scenarios of the future of the universe are kind of depressing and entail our ultimate destruction. But then again, the timescales we are

talking about here are so ridiculously large (think billions of year) that before these might come to fruition, we have probably caused our own demise anyway. But still, it's sort of a sad thought that at some point the universe might just be unsuitable for any type of life. That is, unless of course some very advanced civilization could at some point control the very evolution of the universe and alter it in such a way to suit their own needs.. Who knows.

Luckily, the history of the universe has precisely been such that we have been able to emerge out of the initial chaos of randomness of particles and energy.

Now, having already mentioned two unpleasant scenarios, lets get on with the main topic of this piece, namely another particular and indeed quite catastrophic event that could befall us in the future: the decay of the universe as we know it.

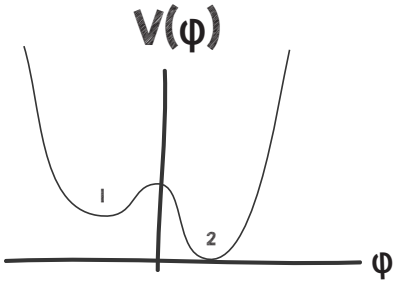
The nice thing about our universe is that the laws of physics allow for the formation of all kind of stable matter out of which stars, planets and we ourselves are built. A priori, this need not have been the case: if one tweaks some of the many physical constants that appear in the Standard Model of particle physics, structure would have had a very hard time to form. Luckily, the history of the universe has precisely been such that we have been able to emerge out of the initial chaos of randomness of particles and energy. However, that does not mean that the universe will remain to be that nice to us.

It might actually be that at some point the values of these physical constants change, leading to the instability of the atoms we are made up off! Atoms that are stable now, will then become unstable in the future, resulting in a swift decay of all the matter we see around us, thus eradicating all the structures in the universe.

Basically for all the physical constants in the Standard Model we have nothing that indicates that they will ever change. However, there is one important exception, which is the value of the Higgs field* which determines key properties of the elementary particles. This value of this Higgs field (ϕ) is in turn determined by the properties of the so-called Higgs potential $V(\phi)$: the Higgs

**Let me remind you of the following. If one wants to unify the theory of special relativity with ordinary quantum mechanics, one finds that one must look at so called quantum field theories. These are relativistic quantum theories, whose basic building blocks are quantum fields that are present in the entire universe, whereas elementary particles can then be thought of as excitations in these fields. For example, photons are simply excitations in the electro-magnetic field, electrons are excitations in the 'electron' field, etc.*

Figure 1



1. Local Minimum (no problem)
2. Possible Global Minimum (problem)

field will acquire a value that minimizes this Higgs potential. Indeed at the present time the Higgs field value is located at a certain minimum of the potential, and the properties of this field value are precisely such that the matter around us is stable.

But here comes the crux: the potential might have other minima that have a lower value than the current minimum. In other words, it might be that the minimum we are in right now is just a local minimum, but not a global minimum. (See Figure 1.) If this is the case, this might have dramatic consequences. Classically it would not pose a problem: once in a certain minimum, whether local or global, the value will stay there because it cannot get over the potential barrier to end up in a different minimum. However, since the Higgs field is a quantum field, it obeys the laws of quantum mechanics which implies that quantum mechanical tunneling from one minimum to another can take place! It doesn't matter that the field doesn't have enough energy to overcome the potential barrier, eventually it will tunnel to the global minimum.

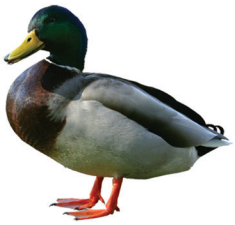
There are thus two possible scenarios. We could currently be living in a global minimum, in which case we don't have to worry (at least about this particular doomsday scenario). But, maybe surprisingly so, experiments at the Large Hadron Collider seem to suggest that we in fact live in a local minimum! Therefore, in principle, we could tunnel to a different minimum thereby suddenly changing all the important properties of the matter around us, resulting in a swift decay of all the structures in the universe! So at one point you could just be goofing around the Francken room, and the other moment you might be swiftly disintegrating into oblivion. Well shit... Just when you were dealt a juicy pithand during a nice round of jassen...

Luckily, even in the case that the conclusions from the experiments are correct, this tunneling will probably only occur in the timespan of billions of years. So I guess you shouldn't worry too much. Just grab a beer from the Francken fridge and get on with your pithand. *En bij deze rust deze theoreet voorgoed zijn koffer.*

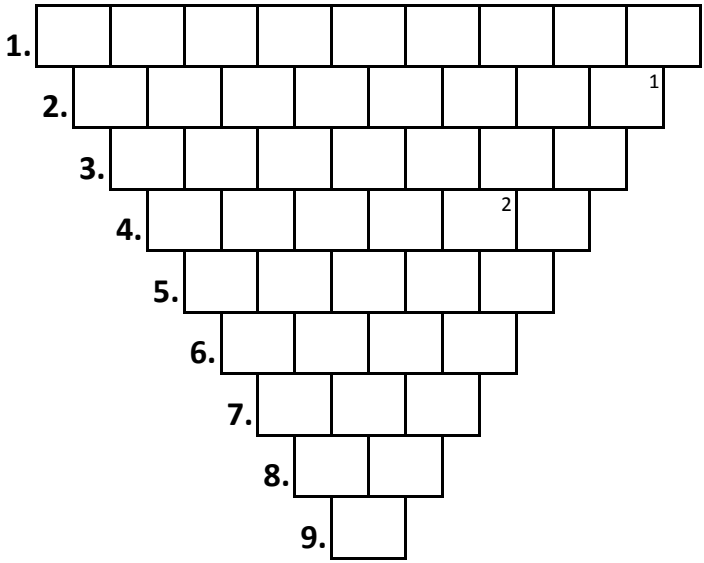
Puzzle

By Steven Groen

Since the easy puzzle in our previous edition was solved by a large number of members, I decided I wanted to make an even easier puzzle for this edition. I made a puzzle consisting of only two descriptions of words. However, something rather odd and completely unexpected happened: decay kicked in. Strangely everyday one letter per word disappeared. The remaining letters managed to form a new word through rearrangement. Not only did this cause a bit of delay, but it forced me to make more descriptions of increasingly shorter words. Although unplanned, this decay resulted in a far more interesting puzzle. Now your job is to find all theser words, such that the six letter solution can be found. Good luck! If you tell us what the solution is, you can win a mallard!



1. E,g, 'Borrelcie, where's the beer?!' or 'Scheids?!'
2. Property of relationships, caves, solids, etc.
3. Near a figure
4. Feline dope
5. Liquid that can become a solid film
6. 473
7. 262
8. How I want a drink, alcoholic of course, after the heavy lectures
9. Fixed point of $f(z)=z^5$
10. People who say things like 'Borrelcie, where's the beer?!' or 'Scheids?!'
11. Not directed towards (feelings of) people
12. To divide by the square root of the inner product (UK)
13. Salt and calcium
14. Property of the theory of relativity, Butters' creamy goo, etc.
15. Related to our previous edition
16. 1609n, with n>1
17. Not entirely
18. Everybody loves this device
19. A name Julie Andrews calls herself
20. Fixed point of $g(x)=x \ln(x)$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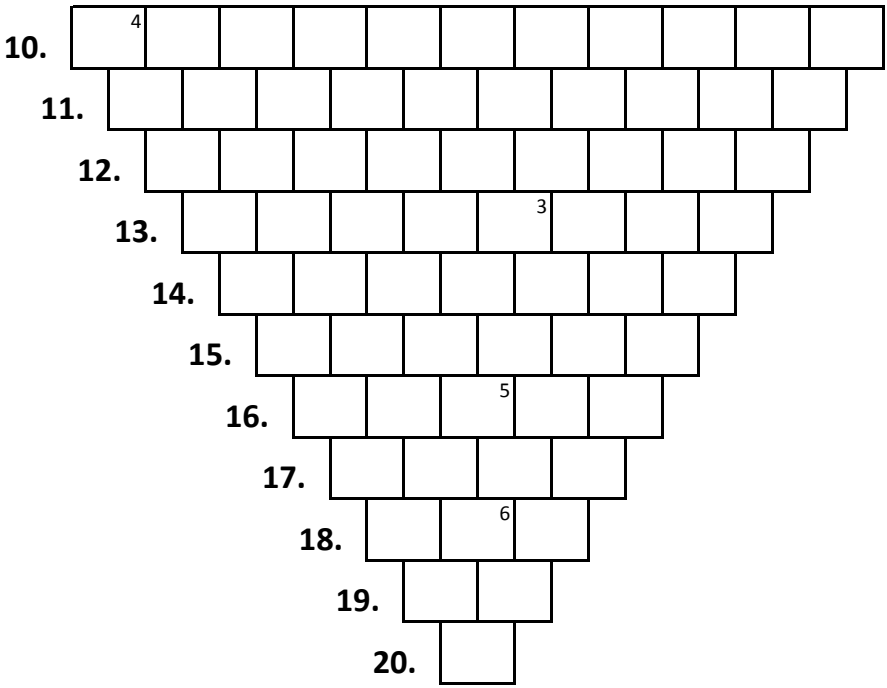
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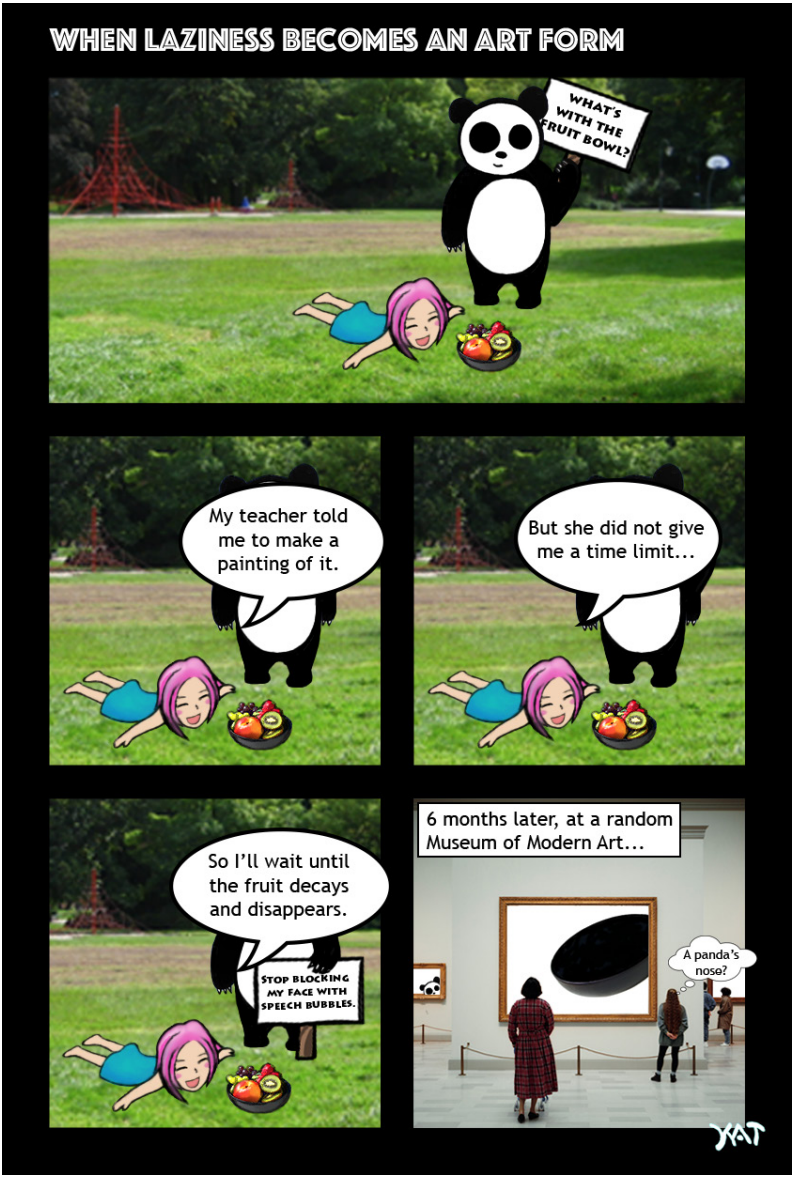

WHEN LAZINESS BECOMES AN ART FORM
WHAT'S WITH THE FRUIT BOWL?
My teacher told me to make a painting of it.
But she did not give me a time limit...
So I'll wait until the fruit decays and disappears.
STOP BLOCKING MY FACE WITH SPEECH BUBBLES.
6 months later, at a random Museum of Modern Art...
A panda's nose?

Alumni Day

By Kathinka Frieswijk, Steven Groen and Sytze Jellema

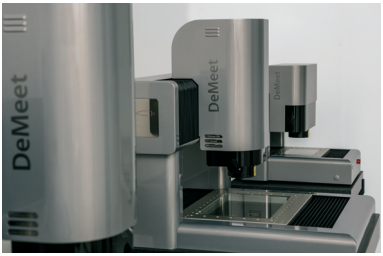
In honour of the semi-lustrum of our praiseworthy association, an alumni day took place in Utrecht on the 20th of May.

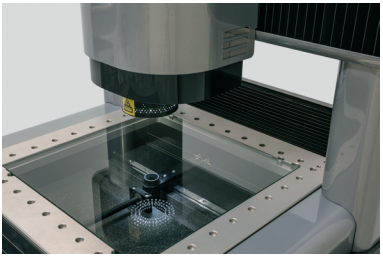
A Francken delegation from Groningen (also known as Utrecht 2.0) undertook a long journey to meet up with old(er) Francken alumni, *compadres* and *mooie gekken.* Many a beers were poured and subsequently consumed. Additionally, the served snacks were downright regal. Due to complaints about exceeding clamor, the squad was forced to take its monkey business elsewhere after some time. Then again, a Francken social wouldn't be a Francken social if we didn't at least get thrown out of some bar. After happily meandering through the streets of Utrecht for a while, we found another bar to occupy, where the fun continued. Pizza was served. It was a day to remember.

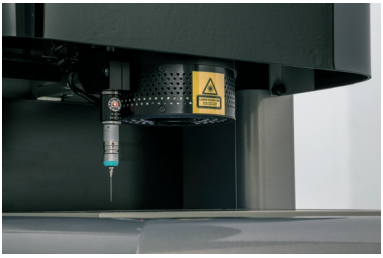
We were able to recollect an excerpt of the sounds that caused the group to be thrown out of location one! Here it follows:

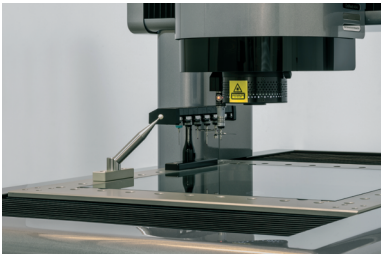
Wij zijn Franckenleden
Franckenleden zijn mooi
Wij zijn mooie gekken
Mooie gekken zijn mooi.

A vast conglomerate of substantially inebriated Francken members roaming the streets of Groningen 0.5, on a quest to find the holy grail: a location at which we could freely sing the song of our people. This holy grail turned out to exist by the name "t Pandje'.









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

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

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

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

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

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