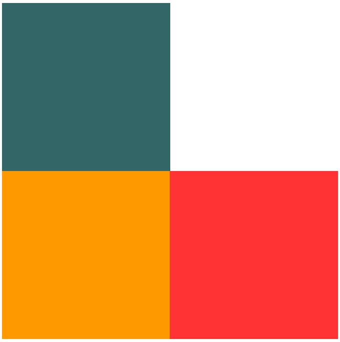
Life after Francken
A story about 10 years after graduation

Francken Abroad
Internship in Singapore

Inside View
Nanosturctured Materials and Interfaces

Francken Vrij

Resolution



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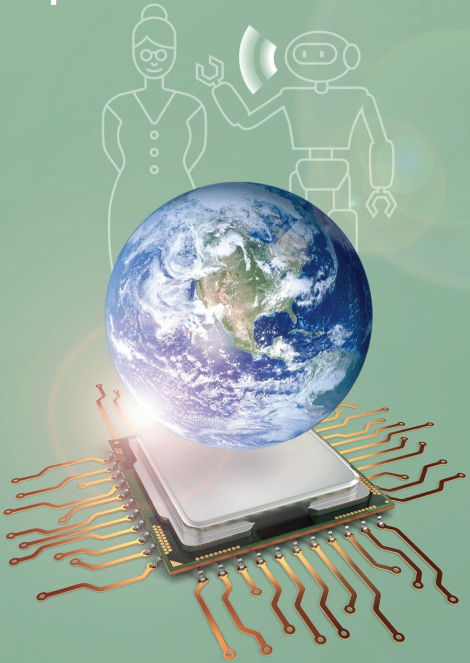

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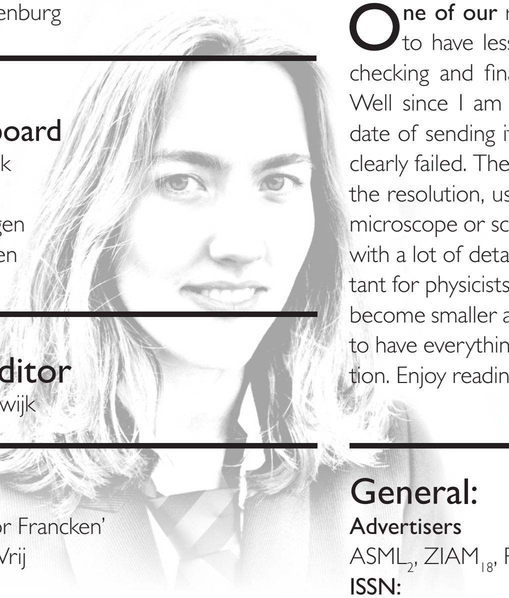

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Dr. Ir. Hedde van Hoorn, Jasper Pluijmers.

Editorial

One of our resolutions for this edition was to have less delay between the layouting, checking and finally sending it to the printing. Well since I am writing this after the planned date of sending it to the printer, our resolution clearly failed. The theme of this edition refers to the resolution, usually defined as the ability of a microscope or screen to show things clearly and with a lot of detail. Of course this is very important for physicists as the things we want to study become smaller and smaller. I hope we managed to have everything in this edition in good resolution. Enjoy reading this new Francken Vrij!

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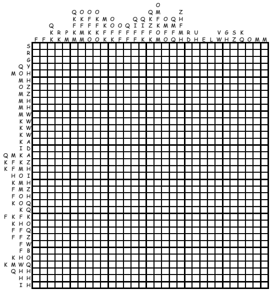

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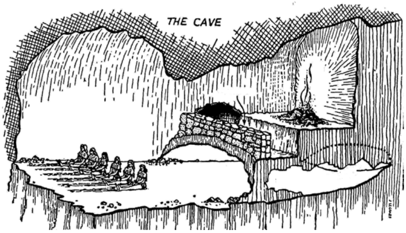

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Also this edition Kathinka has made a comic.

Chair's Preface

By Kathinka Frieswijk

There it was again: the monstrous beast known as New Year's Eve. I almost always tend to end up at some random party where I don't know 95% of the people attending, having to wish strangers 'a happy new year' at the stroke of 12, and then flee the party while having to duck for horizontally flying flares, because the idiots neglected to secure the bottle.

After New Year's Eve obviously comes New Year's Day. If anyone was doing the counting, it is undoubtedly the day on which the most people wake up in a strange bed next to a *broodje shoarma* or a *stokbroodje hummus*, depending on whether they are vegan or not. It is the perfect day to peacefully eat your *broodje shoarma* and calmly reflect on the past year: the progress that has been made and the things that could have gone better. It is very important that this reflecting business is done very slowly, because your head is throbbing and, well, it hurts to think. It is the day on which you design a plan to improve yourself, your life and your future, because "your future is now". Thinking about this quote makes your head hurt even more, because 'now is now' and 'your future is your future', and 'now' is not equal to 'future'. You decide that it makes no sense to spend more time thinking about this, because the person who once said this was obviously the sort of person that shoots his rockets horizontally down the street. It is at this particular moment that you write down your New Year's resolutions: a list of rules that is designed to make you even more awesome than you already are.

Below is a list of some of the most unoriginal New Year's resolutions and tips to help you achieve them:
1. *Join a gym*. A lot of Francken members still actively play Pokémon Go, so if you tag along with them you can very easily join a gym every single day.
2. *Go on a diet*. An unhealthy diet is still a diet. Francken has a wide selection of products, such as chips, chocolate, noodles, and even satay sticks. Sadly no *broodje shoarma*.
3. *Travel more*. Join our foreign excursion (buixie) to Portugal in April!
4. *Get organised*. You can practice organising yourself by joining a committee and organising events.
5. *Live life to the fullest*. Apply to become a Francken board member for the full experience! Also, eat potato chips while watching 'Obese', it is so damn relaxing.

News of the Association

By Anna Kenbeek

When we are talking about resolution, I would like to hightlight two different meanings. The first meaning has to do with the future: New Year's resolutions, or the firm resolution to study more, do more sports or have more fun. The second has to do with the past: high-resolution photos of past events. Both are applicable on activities of T.F.V. 'Professor Francken'. Only a few months have passed since the last Francken Vrij. A thousand words say almost as much as a photo, so I will give you a short recap of what happened within the association.

Jam session

I start off with one of my favourite activities of this year. Even though a lot of songs are being played on the Francken piano in the members room, this is not everybody's jam. During the jam session we got to see some very talented musicians, as well as some funny songs by committees and the board, and some good improvisation.

Klaverjas tournament

The game Klaverjassen is far from extinct. During the Klaverjas tournament all participants teamed up in teams of two and pretended they knew how to play Klaverjas. Nonetheless, some of them actually did! Prizes were awarded to the best teams, while the others made resolutions to practice for next year's tournament.

Crash & Compile

The Crash and Compile was a programming competition where less or more capable programmers teamed up in teams of two. The aim of this competition was to reach your Ballmer peak by writing scripts in order to get the right answer to several questions: if you obtained the right answer, you would get 'bitterballen', but if your answer was wrong, you would have to drink. Both options don't sound so bad, right?

Tour de Francken

The yearly Tour de Francken, also known as just 'the tour' took place again! It was challenging to get through all the longer stages and mountain stages as fast as possible. Seven teams participated and the result may be too close to call, but in the end 'Teampje Onzin' won and 'Borrelcie Hoog' got their second place. The two FMF teams and the freshmen team weren't bad either. It was an exciting tour.

Sjaars Dinner

The Sjaars Dinner was the first activity organised by the First Year's Committee: an entirely Irish-themed dinner, with Irish food, decoration and even music. No less than about 45 people showed up and enjoyed a well-cooked meal made by our relatively new members. In addition, in March they will surprise us by their 'MS paint' party!

Ice Skating

The Sports Committee goes big regarding winter sports. They took us ice skating in Groningen and for members that want to do something even cooler, they planned to go snowboarding and skiing in the alpincenter in Bottrop. Anyway, the ice skating clinic was very entertaining. Some of us still had to learn how to stop, others learned how to go faster or obtain better techniques. Besides some technical advise, we also got the chance to do a race in couples. We are looking forward to snowboarding!

Practice Sessions

As always, several Practice Sessions for first and second year Applied Physics courses were organised. This time there was a chance to go to the Practice Sessions for Statistical Physics, Mechanics and Relativity, Waves & Optics and Linear Algebra 1.

Francken-ZaZa gala

Every year a gala is organised together with the study association for Dutch culture and language, ZaZa. This year's gala was not only in a beautiful location and with a special dress code, 'masquerade ball,' but also Professor Vladimir, a band consisting of Francken members, gave a great live performance. While listening to some good old hits, we all had an enjoyable night.

Upcoming activities

The - in my opinion - two best activities of a year at Francken are nearing: First, this year's Symposium takes place on May 2, on this day speakers will tell something about 'power from within'. Second but not least, the Foreign Excursion to Portugal is planned from April 14 to April 22.

Life after Francken

By Dr. Ir. Hedde van Hoorn

It has been a while since a contribution of mine appeared in the Francken Vrij. My last article in FV was another edition of Life after Francken [FV 14.3]. I was shocked to look back and discover that I already had a life after Francken in June 2010 - almost 8 years ago! Thinking back even further, this year will mark 10 years since my graduation. A lot has happened since I completed 6 years of applied physics in Groningen.

When I started thinking about what could be a useful storyline for this article, I thought back to my time as an almost graduate. Taking a next step at such a pivotal point in life is difficult indeed. And even though the short term of such a step can be cloudily envisioned, the long term is often nearly impossible to imagine. So here I am; possibly ten years from where you are. In this article I would like to guide you through my time as a student into someone whom strangers call "sir" nowadays. Perhaps I can sketch an image of your possible future in higher resolution.

Studious enjoyment

I was never totally convinced that physics was meant for me. But before I knew it I was attending Differential and integral calculus by Jaap Top, a caricature of a mathematics professor still at your university. I was struck immediately by his archetypical confused scientist look complete with bushy moustache and slippers teaching mathematical proofs on a huge blackboard. Physics life had begun. In many more physics and math classes none of these walking stereotypes ever managed to scare me away. And above all, I found a band of brothers (and a few sisters) going through the same sh*t: the T.F.V. 'Professor Francken'. Here I found friendships, lasting to today and I hope well into the future. Just last weekend the infamous Technisch Fysisch Heren Dispuut 'Dum Spiro Bibo' convened for their annual SinterPaasHaas. If not for the recent- and near future- fatherhood experience exchanges it could almost have been an old-fashioned student party. Life continues, yet the friendship was forged solidly during our student years some 10 years ago.

> *I felt like I had only caught a brief whiff of the world of physics.*

I enjoyed my years as a student tremendously; maybe even more so in hindsight than at the time. During my student days, I was immersed in a lot of beautiful physics that I did not recognize or appreciate as much as I do now. With that appreciation I also took some turns in my career later on. But in 2008, I felt on top of the world when I graduated from applied physics in Groningen.

The fast life

Upon finishing my Master's degree in Groningen, I did what any good socialite and ambitious physicist would do; I became a consultant. Recently, Arjan van der Pal sketched a good image of what that means [FV 21.3]. I worked for a small strategy firm called Thaesis. Back then, we (or they? I guess I still feel part of the team) had an office in Utrecht. Nowadays they are located in a fancy villa in Hilversum. Because it was such a small team, I worked directly with one of the founding partners most of the times and, of course, with the team of young, very smart and hard-working colleagues. I worked mainly for media companies and within my first half year even attended meetings with CEOs in that field. I enjoyed this time and learned a lot. However, the challenge in the truly analytical work is somewhat limited (sorry Peynacker) whereas the social-managerial-business component quickly became the dominating factor for how successful you are. Even though I was developing the latter interesting new skill set, I felt like I had only caught a brief whiff of the world of physics. So after 15 years I decided to re-orient my horizon completely, yet again.

In my previous contribution [FV 14.3], I had already described my homesickness. In this case, home refers to the mental home of a physicist. Because even though having lunch on a rooftop terrace in Rotterdam displaying your latest tailored suit is fun, I missed physics. Mind you, I do not and never did regret my initial career choice. The main theme of my entire career trajectory up until now seems to be that it's never too late to change. And I see that theme play out in former physics students around me as well. We - as well-educated physicists – are a scarce commodity in professional circles and therefore occupy a privileged position in society. I took advantage of this position when I changed my physics-student hat for the tailored suit of a consultant.

Keep learning

What other degree can you pursue if you want to keep doing physics? That's right, I decided to look around for an interesting physics PhD position. During my studies in Groningen, I had done interesting materials science research in the group of professor de Hosson, surely well known by everyone at T.F.V. 'Professor Francken'. Already during my student days, after studying high-alloy steel and aluminum foam structures, I had felt that it was time for something different. So for my research internship, I went to MIT in the USA to investigate the effects of stiffness on red blood cells when malaria parasites use them as a vessel to reproduce. The physical approach to biology (the field dubbed biophysics) still fascinated me after my consulting adventure, so I decided to look for research in that field as well.

Even though I had been out of physics for a bit, the group of professor Schmidt at Leiden University accepted me for a PhD position in 2010. My research the following four years focused on experimentally investigating the mechanical behavior of eukaryotic cells, which are a lot more complicated than red blood cells. And so I became immersed in the fast growing sub-field of biophysics called mechanobiology. Only 4 years earlier, a seminal paper by Engler et al. (Cell, 2006) had shown that the stiffness of the environment of a stem cell directly influences its lineage. This feat was previously completely unknown. Within the biophysics community, this discovery and other similar interests spawned many new research programs and I was working on one of them. I did my PhD in a collaborative research effort called the Dutch Mechanobiology program.

Especially exciting in this research was how many different specialties and fields come together. We used advanced (home-built) optical microscopes, biology that went far beyond my own capabilities and microfabrication to make devices that can measure the tiny forces a cell exerts on its environment. As is always the case in research, we did not answer the very general question of how stem cells differentiate depending on stiffness (this question still does not have an answer). But we did make steps in a couple of very specific fields and most of all, failed many times. In particular, I worked on incorporating super-resolution microscopy (very suitable for this Francken Vrij edition) in measurements of cellular forces (van Hoorn et al., Nano Letters, 2014). Finally, after 4.5 years of lab-work, writing papers, teaching physics and producing a thesis, I am now allowed to call myself dr. ir. Hedde van Hoorn.

Figure 1: A new doctor among doctors and professors.

To research or not to research

So the research bug had bitten me, and I was faced with another crossroads. Even though I had enjoyed the world of biophysics greatly, I could do with a bit less bio (unpredictable experiments that often don't work without reason) and a bit more physics. During my PhD time I had collaborated (among others) with professor Iannuzzi at the VU University in Amsterdam. There, he leads a group that engineers very small interferometers to make miniaturized all-optical measuring devices that can be used for (internal) medical applications. In simpler words, we made small devices that measure stuff with light (albeit 1550 nm IR light that you actually can't see).

My focus shifted more towards physics and engineering and away from cell biology. As a post-doc, I was able to do very diverse work again with several PhD students and guiding several student projects (bachelor and master, as I also did during my own

PhD). However, when you walk down the road of research, a clock is always ticking.

> *As a physics lecturer, I again get to do a plethora of fun stuff.*

If you want to grow to the position of group leader and some day full professor at a university, your daily focus must at some point shift from doing research towards setting up your own research line and above all obtaining grants. So the very nature of your work changes and the imaginary clock for important grants starts ticking the moment you obtain your PhD.

So in my second year of post-doc I started thinking about my own research direction, while simultaneously starting a family. In my personal life, I became known as dad to my oldest daughter and am now lucky enough to have relived that experience recently. With that major personal change, I also started re-thinking my professional life (again!).

So I thought long and hard about what I really enjoy doing; and I did enjoy my job at the VU! I enjoyed thinking about difficult (physics) problems, doing research in the lab and most of all working with eager and curious young people who want to learn and grow. In that process, I often ended up explaining certain concepts, dove into the physics and tried to help the group. But my work was changing; I needed to go "up the ladder". In the end, I decided to look around to see if there would be a place where I could contribute more to the personal growth of young people who want to learn about physics.

Back to school

Finally, I applied to a teaching position in applied physics at The Hague University of Applied Science (THUAS, De Haagse Hogeschool in Dutch). We have a full Bachelor of Science curriculum where a team of lecturers educates a variety of core courses, well known to all of you. We basically teach the bachelor's physics curriculum in 4 years starting from a HAVO degree. The job offered more of the things I was looking for professionally, so I took it when it was offered to me.

As a physics lecturer, I again get to do a plethora of fun stuff. I teach some courses as the main lecturer, in others I work on practicals, then on other days I help with research projects or guide research internships where I visit technical companies and research institutes that host one of our students. Recently I even visited the University of Groningen where one of our students was automating an angular reflection spectroscopy setup in the group of professor Stavenga in good old building 13.

In terms of the content; I get back to basics with thermodynamics, mechanics, optics and many more topics. My daily job is within a team of about fifteen physicists who all have a true passion for teaching. And of course I spend a lot of time teaching and discussing physics with a bunch of 17-23 year olds. What else do you want?
So in the end I get to interact with the eager young minds of young adults who are in the most crucial stage of their lives, just like many of you. The world is at your feet and this is the time when you develop into adults (although you may think you already are there, of course). And it really doesn't matter if you don't yet have a clear picture of your future. Just make the best decision you can and give it all you've got. And never be afraid to stop and re-think your course. I did so several times and am doing just fine.

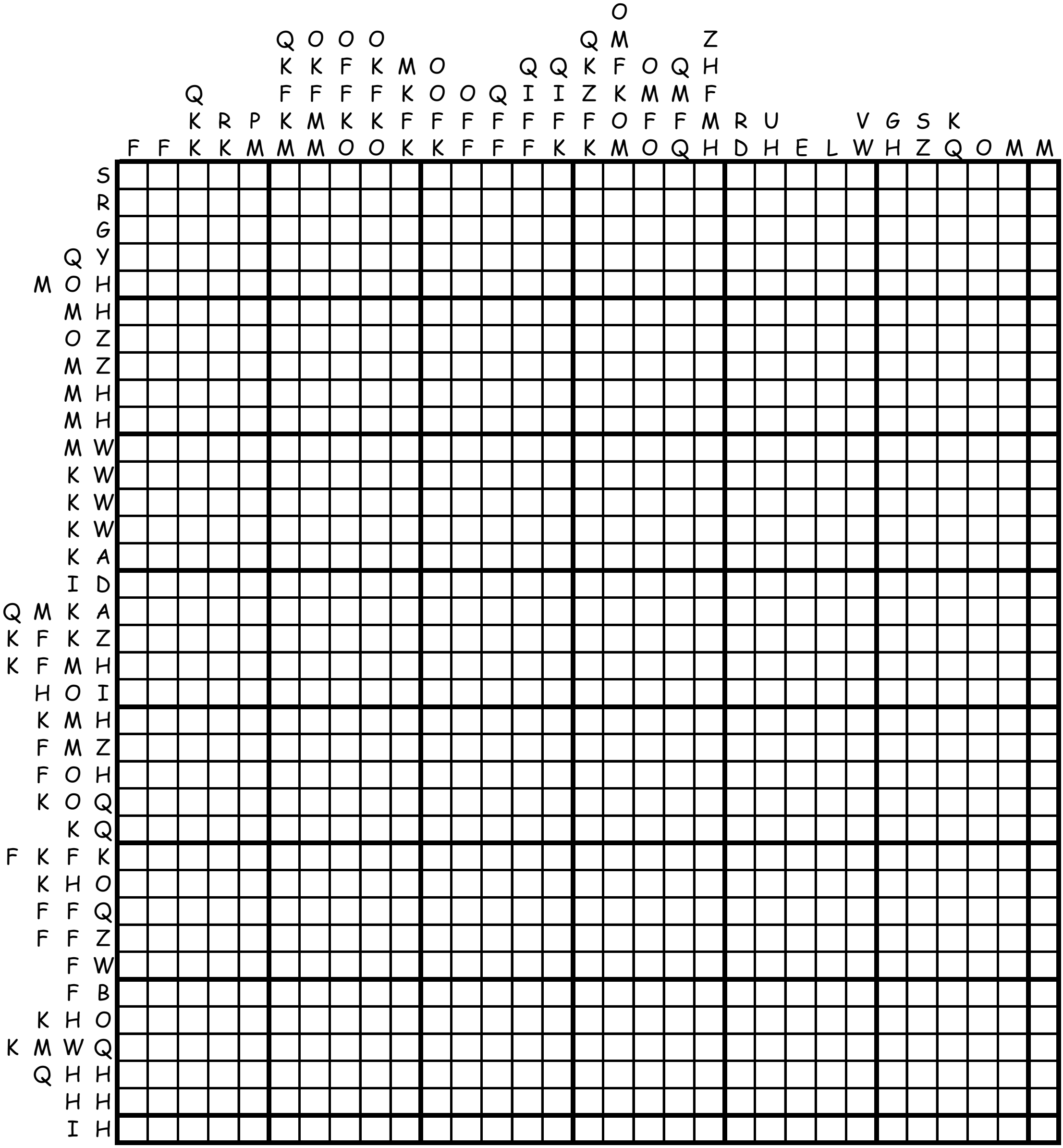
Figure 2: The Iannuzzi group at VU Amsterdam.

Puzzle

By Steven Groen

In light of the current theme, I decided to make a puzzle whose resolution is an image of a particular resolution: 1116 pixels, that is 31 by 36. This puzzle, which I call a bobogram, resembles a nonogram, a *Japanse puzzel*: the numbers at the top of colums and at the left of rows represent the size of the connected components in that column or row. But there is a catch. As you may have noticed, there are no numbers in the bobogram; there are only letters there. Before you engage in your adtempt to get the picture, you must find out which letter is appointed to which number. For this, I have been kind enough to provide the following hints. Good luck! E-mail your resolution to the editorial board, and you might receive an exclusive dinner with us. If you have an idea of what is pictured in the resolution, we'll make a dessert for you.

A: A highly composite number.
B: Not a palindrome.
D: This integer equals QM, and differs less than Z from S.
E: U+Q+F.
F: S-ZK.
G: F+K+O+Q+Z.
H: This integer multiplied by itself is not only divisible by this integer, but also by its square. Moreover, this integer divided by itself is in fact a square that divides this integer added to itself. Finally, this integer can be written as the sum of two irrational numbers.
I: The number of issues of Francken Vrij that appear in *n* years, where *n* is the number of issues of Francken Vrij that appear in a year.
K: The square root of U/Z.
L: An integer sometimes associated to the reversal of interior and exterior.
M: This non-square integer is not a divisor of L.
O:(V+I-L)P+W-Z+K.
P: A triangular number.
Q: A divisor of E/K.
R: This integer equals $(E-L)^{E^2+L^2-2EL}$, and if you rotate it, it will become divisible by both H and S.
S: No other multiples of this prime occur in this puzzle.
U: The greatest integer that cannot be written as 5a+7b+1, with a and b non-negative integers.
V: HO-I.
W: A cube that is the sum of two squares.
Y: BW-(H+D)M.
Z: U/K^2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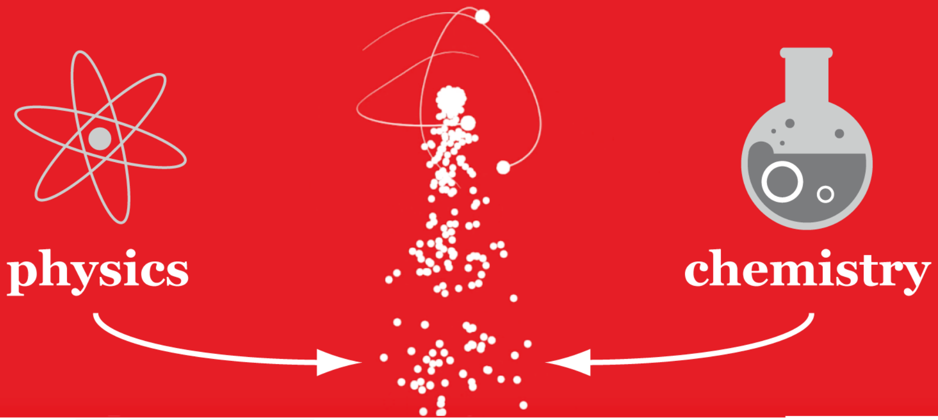

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MgTi bimetallic nanoparticles for hydrogen storage

By Gopi Krishnan[*a,b], Sytze de Graaf[a,] Gert H. ten Brink[a], Marcel A. Verheijen[c], Bart J. Kooi[a], and George Palasantzas[a].

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This edition we have an inside view in the research of the Nanostructured Materials and Interfaces group of professor Kooi and professor Palasantzas. They investigate the relation between nanostructure and functional properties of materials. The research focuses on material structure, surfaces/interfaces, and surface interactions at the nanoscale. This includes research on phase change materials, nanoclusters/nanoparticles, nanoresonators, surface forces, friction, and adhesion.

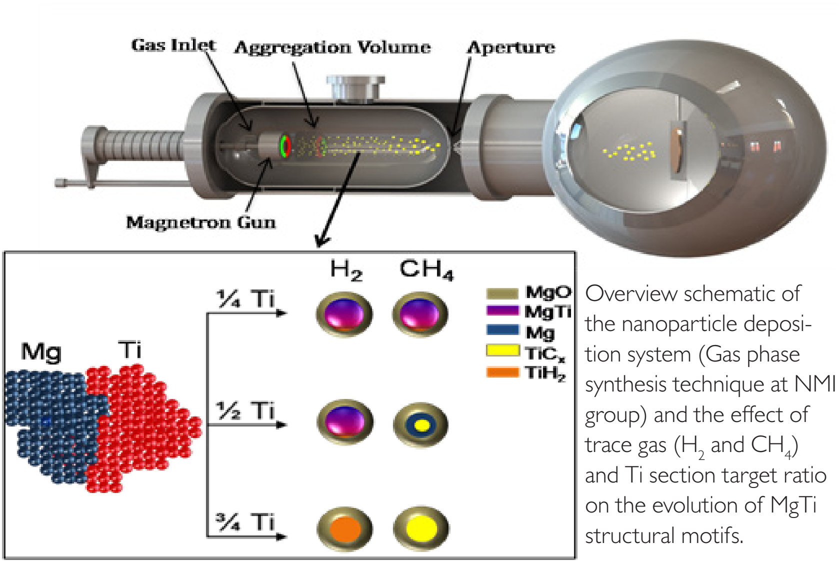
Introduction

Magnesium with its lightweight and high gravimetric capacity of 7.7 wt% for hydrogen has attracted strong interest for potential use as a hydrogen storage material[1]. Though it is a promising material, it suffers from poor kinetics and thermodynamics of hydrogen absorption/desorption. Kinetics has been improved by nanostructuring, alloying and by adding catalysts[2-4]. Interestingly, Mg based alloys consisting of immiscible elements e.g. Ti that was synthesized using a non-equilibrium method appeared to improve the kinetics for thin films, and ball-milled particles with good reversibility [5-7]. It has been concluded that the cubic-based fluorite structure of $MgTiH_x$ compared to tetragonal-rutile structure of MgH_2 is the important reason behind the improvement[5, 8-10].The synthesis of immiscible bimetallic nanoparticles (NPs) using a non-equilibrium method based on gas phase synthesis is interesting because it opens a broad range of elements that can be tried, and also has a clear advantage in synthesizing different structural motifs over other synthesis methods[11-13]. However, the thermodynamic stability of MgH_2 with its enthalpy of formation of -75kJ/mol is a formidable barrier for applications and still remains an important challenge to overcome[1]. It is believed that the reduction in enthalpy of MgH_2 can effectively reduce the temperature of desorption to a much lower value that is interesting for practical use.

Although with spark plasma synthesis of MgTi nanocomposites the enthalpy of MgH_2 was reduced to -45 kJ/mol, despite the better hydrogenation kinetics it did not show the corresponding reduction in desorption temperature[12]. On the other hand, gas phase synthesis of MgTi NPs using an evaporation method did not show any reduction in the enthalpy of MgH_2, though they showed improved kinetics of hydrogenation and dehydrogenation[13]. Similarly, other reports on MgNP confinement in a matrix/scaffold, which showed the reduction in enthalpy, considered that the effect of enthalpy reduction is compensated or counterbalanced by the entropy reduction, which finally does not affect the desorption temperature to the expected value[14-16]. The reason for these differences is still not well understood.

Hence, in order to understand the underlying reason for such differences, a good control over the synthesis method is necessary for tuning size, shape, composition and interface of each individual NP to unravel the corresponding effect on enthalpy. Although such studies on the effect of size and shape of Pd NPs have been performed earlier that showed the change in hydrogen absorption behavior compared to the one of bulk Pd[17-19], extending these methodologies to Mg and MgTi based NPs is still very challenging. It is understood that a detailed analysis of the interface, shape, structure, strain and orientation is a key to unravel the nanoscale effect on MgH_2 destabilization on a single MgTi NP. In this respect, the gas phase synthesis based on DC magnetron sputtering in comparison to other gas phase methods has attracted attention for the controlled production of NPs with tailored size, composition and various structural motifs for both bi- and trimetallic NPs[20-22]. Nevertheless, extending to Mg based nanoparticles is still challenging due to the difficultly of Mg nucleation and its high affinity for oxygen[21-23].

Moreover, controlling one specific structural motif over other structural motifs in combination with a uniform deposition of NPs on a substrate also remains a challenge. Nevertheless, we recently reported that the nucleation issue of bimetallic NPs and especially Mg can be solved, and their corresponding NP production rate can be enhanced and maintained for several hours of deposition by addition of trace gas[23].



Overview schematic of the nanoparticle deposition system (Gas phase synthesis technique at NMI group) and the effect of trace gas (H_2 and CH_4) and Ti section target ratio on the evolution of MgTi structural motifs.

Specifically, the addition of H_2/CH_4 as a trace gas for nucleation, along with tuning structural motifs, is interesting because it could favor the insitu formation of hydride NPs in the plasma depending on the element used.

As part of this work we studied extensively the influence of H_2 and CH_4 on the nucleation and growth of MgTi NPs, with the main focus on controlled synthesis and structural analysis of NPs. This type of in-depth analysis of MgTi NPs is essential for hydrogen storage systems.

Results and discussion

Figure 1(a) shows a Bright Field TEM image of MgTi NPs synthesized using a section target of Mg and Ti. The size of the produced NPs is approximately 40 nm, and shows a hexagonal shape in projection of the hexagonal closed packed (HCP) crystal structure. The HCP structure was confirmed by resolving the low index {10-10}, {0002} and {10-11} planes from the SAED pattern shown in Figure 1(b). The NPs have a composition of 88±3 at% Mg and 12±3 at% Ti as measured by EDX.

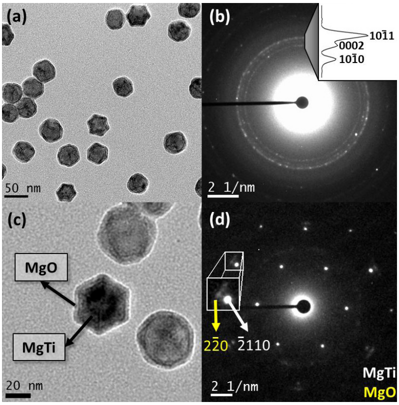
The projection of the NP along the Mg [0001] axis shown in Figure 1(c), indicates that the NP is faceted by the {10-1 i} planes, where i is an integer i.e. the prismatic or pyramidal planes. Furthermore, the particles are often viewed along the Mg [0001] direction, which suggests that the NPs are also faceted by {0002} planes. The single NP SAED pattern shown in Figure 1(d) shows also the presence of an MgO shell with {220} planes that confirms the presence of crystalline oxide shell. The presence of thin crystalline MgO shell of MgTi NPs is similar to pure Mg NPs as reported earlier[24-26], being important for their relatively high stability.

A series of bright field TEM images captured over a large tilt angle range (-65 to +65 degrees) are 3D reconstructed (tomography) to obtain a 3D visualization of the NP shape, as shown in Figure 2. The NP shape resembles very well a truncated hexagonal pyramid where the facets consists mainly of {10-11} and {0002} planes. Indeed, HRTEM viewing along a direction orthogonal to the [0001] direction shows that the (0002) plane is parallel to a facet. Notably, viewing along this direction confirms that the side facets are not parallel to the Mg {10-10} planes as it was observed for pure Mg NPs[25], but rather are Mg {10-11} planes. The MgTi NPs were only synthesized using Ar as a sputtering gas without the supply of any trace gas. It must be stressed that the NPs shown in Figure 1 were observed only a few times during NP deposition as most of the NPs produced have a core/shell (Ti/Mg) structural motif. The observed structural motif in the latter case was due to a formidable limitation of Mg nucleation that we recently reported[23].

The thermodynamic equilibrium shape of pure Mg and Ti crystals has been predicted by applying the Wulff construction based on DFT calculations of surface energies. The fractional contribution of the predicted surface planes for Mg have been estimated to be 38% {10-11}, 37.8% {10-10} and 24.2% {0001}, whereas Ti consists of 55.5% {11-21}, 24.5% {10-11}, 17.2% {0001}, and 2.8% {10-10} planes[27].

Note that Mg is predicted to be faceted

Figure 1: (a) Bright-Field TEM image of Mg88Ti12 NPs grown in an Ar gas environment, and (b) their corresponding SAED pattern.(c) Bright-Field high magnification TEM image of an Mg88Ti12 NP, and (d) its corresponding SAED pattern viewed along the [0001] axis of Mg. The HCP MgTi and FCC MgO planes are indexed in white and yellow, respectively.



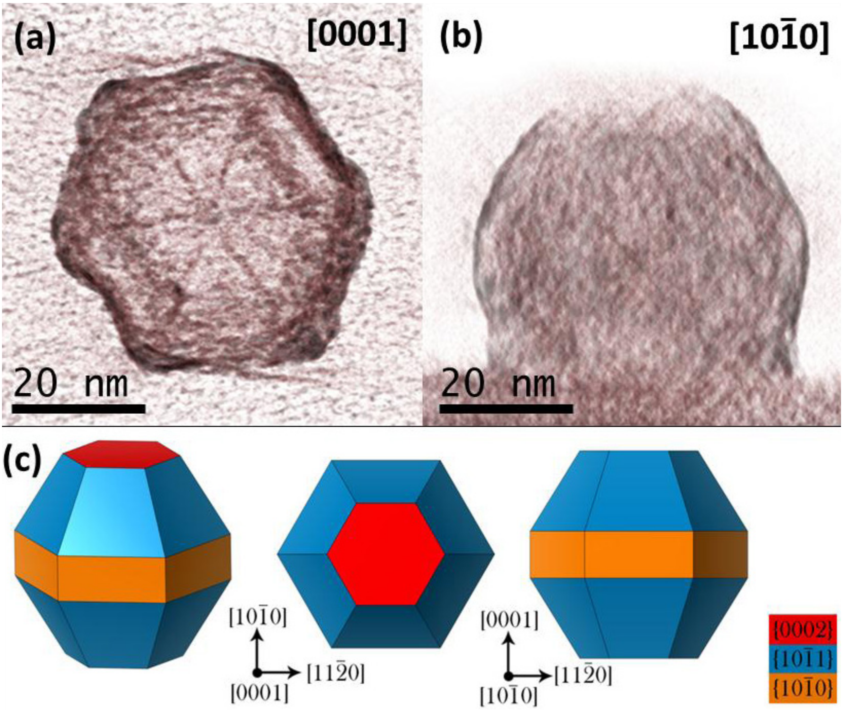
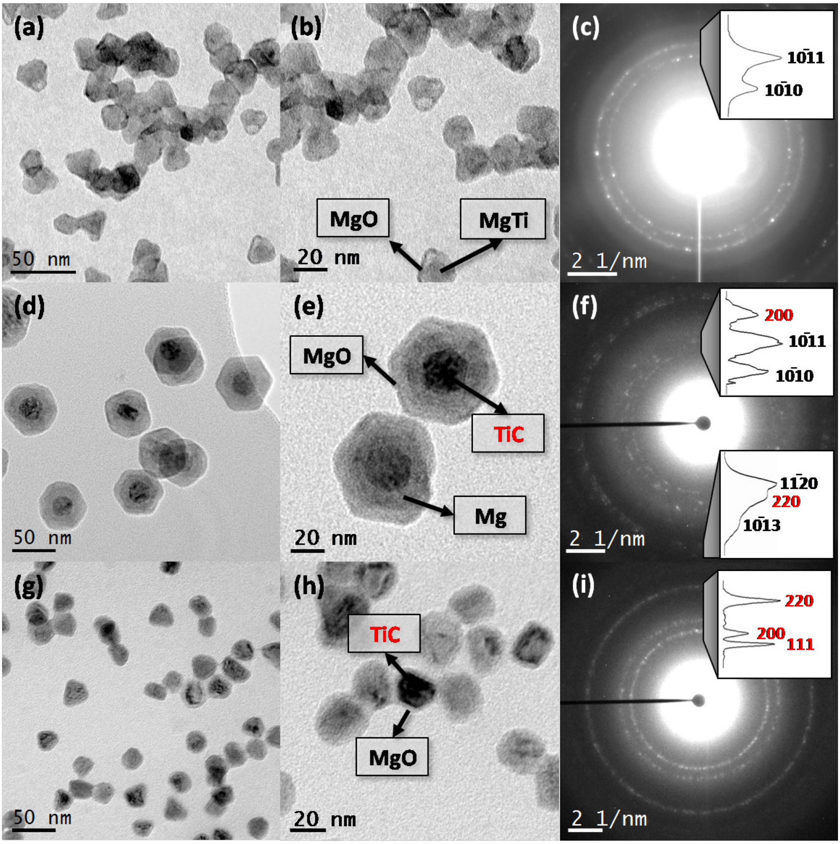


Figure 2: 3D reconstruction of the particle shown in Figure 1 (c). (a) Shown along [0001], and (b) shown along [10-10] normal to a facet. (c) The NP's shape based on the 3D reconstruction and the SAED patterns of the present work.

Figure 3: Bright-Field TEM image and SAED pattern of MgTi NPs synthesized using CH_4 *as a trace gas and various section target ratios. (a,b)* $Mg_{86}Ti_{14}$ *NPs with solid solution structural motif produced using ¾ Mg + ¼ Ti. (d,e)* $Mg_{85}Ti_{15}$ *NPs with core/shell/shell structural motifs produced using ½ Mg+ ½ Ti. (g,h)* $Mg_{45}Ti_{55}$ *NPs with core/shell structural motif produced using ¼ Mg + ¾ Ti. (c) corresponding SAED pattern of (a,b) MgTi planes are indexed in black. (f) corresponding SAED pattern of (d,e). (i) corresponding SAED pattern of (g,h).The HCP Mg and FCC TiC planes are indexed in black and red, respectively.*



as a hexagonal prism, while Ti is predicted to form a hexagonal pyramid and in both cases truncating the vertices reduces the surface energy. The former prediction corresponds well with previous observations of Mg NPs, while the combination of the two is similar to what is observed for MgTi NPs as it is shown in Figure 2(c). This implies that a slight amount of Ti present in the particle as a solid solution affects the surface energy of particular crystal planes. Therefore, the alloyed structure increases the {10-10} surface energy, while decreasing the {10-11} surface energy. This results in an NP shape that is predominantly faceted by the {10-11}, and {0002} planes.

Figure 3 shows the effect of methane as a trace gas to initiate and sustain the MgTi nucleation process, which otherwise ceases as Mg and Ti stops nucleating[23]. Figure 3(a,b) shows a Bright-Field TEM image of MgTi NPs synthesized using CH4 with a section target of ¾Mg + ¼Ti. The corresponding SAED pattern in Figure 3(c) shows that the MgTi NPs are solid solution of Mg and Ti. This can be confirmed by the interplanar "d" spacing measured from the diffraction pattern, which shows a clear deviation from pure Mg similar to our previous work[23]. Once the target composition is changed to increase the percentage of Ti concentration (½Mg+ ½Ti), the MgTi NPs produced shows a core/shell structural motif. The target composition was changed due to the very low concentration of Ti observed in the NPs produced in the case of ¾Mg + ¼Ti. Moreover, the increase in Ti concentration also modifies the MgTi NP final structure from HCP to FCC, where for the latter the formed hydride has better absorption kinetics than the former[7,9]. Figure 3(d,e) and the diffraction pattern shown in Figure 3(f) reveal that the core is made of TiC_x and Mg/MgO as shell. HCP Mg is identified from the resolved low index {10-10}, {0002} and {10-11} planes with the corresponding interplanar distances that matches those of pure Mg.

Figure 4 shows MgTi NPs produced using H_2 as a trace gas to further investigate the effect of the gas environment on the nucleation, structure and shape of the produced NPs. Addition of H_2 as a trace gas will not only resolve the issue of nucleation but also can favour insitu formation of a hydride phase that is more desirable for hydrogen storage materials than the ones with a TiC_x core that is formed using CH_4 as a trace gas. Our experimental investigation with H_2 as a trace gas and a ½Mg + ½Ti section target shows NPs in Figure 4(a,b) with a solid solution structure. However, as the composition of Ti is increased to 75% (using a ¼Mg + ¾Ti section target), the NPs produced have a core/shell structure of TiH_x/MgO as shown in Figure 4(d,e).This structural motif resembles the NPs produced using CH_4 as a trace gas, which shows the formation of TiC_x/MgO core/shell structure. Note that the addition of H_2 as a trace gas to a section

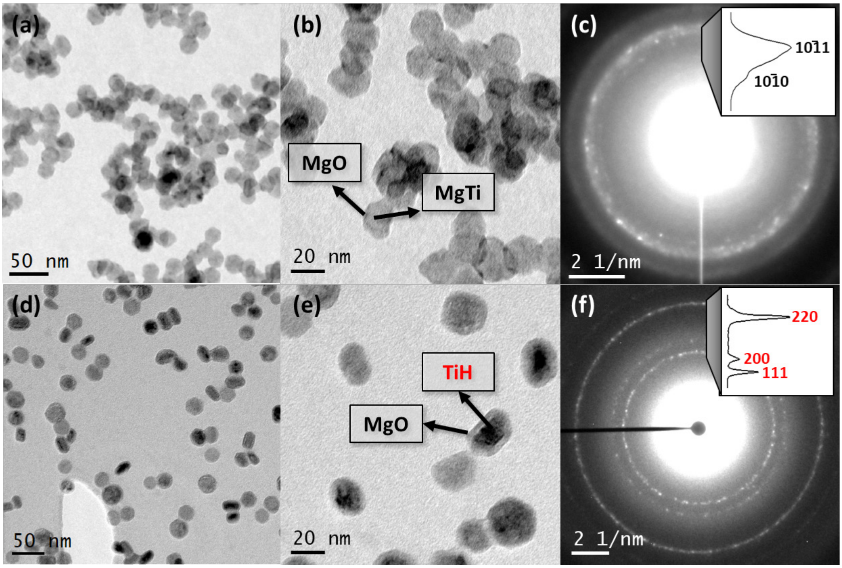


Figure 4. Bright-Field TEM image and SAED pattern of MgTi NPs synthesized using H2 as a trace gas and various section target ratios. (a,b) $Mg_{86}Ti_{14}$ NPs with solid solution structural motif produced using ½ Mg+ ½ Ti. (c) corresponding SAED pattern showing the presence of HCP MgTi. (d,e) $Mg_{47}Ti_{53}$ NPs with core/shell structural motifs produced using ¼ Mg + ¾ Ti. (f) corresponding SAED pattern of TiH.

target of ¾Mg + ¼Ti also showed the solid solution structure similar to NPs observed with a section target ½Mg+ ½Ti.

In summary, we have shown the effect of CH_4 and H_2 as a trace gas on the MgTi nucleation and growth sequence, which allows tuning of the structural motifs and shapes of MgTi NPs. Our results show that many structural characteristics of MgTi NPs depend strongly on the composition of the target and the choice of trace gas. In most cases the MgTi NPs form a core/shell structure, where an Mg and MgO shell surround a TiC_x or TiH_x core, and in some cases a solid solution of MgTi is observed.

For the detailed publication see: DOI: 10.1039/C7NR06771B (Paper) Nanoscale, 2018, 10, 1297-1307.

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Francken Abroad

By Bauke Steensma

Some people might think of me as the guy whose interests lay in sport-fishing and modern dance [FV 16.3, p. 9]. However, I assume most of these people are long gone. Therefore, this is a good chance and opportunity to reintroduce myself: I am Bauke, and I've been a member of Francken since 2010. In my first year I was not very active at the association. Be that as it may, the moment I decided to become an active member, I decided to go all in and be a part of the board of year 2012-2013 titled 'Binnenstebuiten'. In the following years, I spent a lot of time for and at Francken, being a part of a multitude of committees.

The last two and a half years my focus shifted towards finishing the master Applied Physics, including one of the major requirements: the internship. As you might have understood from the title, this article will focus on my time abroad, and that is exactly where the internship comes into play. It was in the last few months of my master research that I started looking into the internship. During this time I was in the photophysics and optoelectronics group of Prof. Maria Loi, and needless to say, I asked her for help concerning the internship. Professors commonly have many connections, and Prof. Maria Loi is definitely no exception. She investigated the possibilities for an internship within her research field and provided me with several options, which I greatly appreciated. One of the options was a position in Singapore, which spiked my interest, as I had always wanted to live abroad, especially outside of Europe. Singapore is one of the most modern, multicultural, and intellectual countries in the

Singapore

world, while also being located in Asia. This made it an easy decision.

Many of the Applied Physics internships are performed in industry. Mine was slightly different, since I was a researcher at the Energy Research Institute connected to the Nanyang Technological University. My topic was on device studies of tandem solar cells. As the name suggests, these devices consist out of two or more solar cells in conjunction with each other, where one is stacked on top of the other. Tandem solar cells can, in theory, reach efficiencies higher than 33%, which is the so called Shockley Queisser limit for single cells.

Fines can be expected for smoking at a station, up to one thousand Singapore dollar.

In the tandem project I was working on, the bottom cell consists out of a silicium cell (commonly seen on roofs of houses), while the top cell is a perovskite solar cell. Marten Koopmans previously [FV 22.1] explained the workings of a LED made out of perovskites, while the perovskite structure was explained by Prof. L.J.A. Koster in Francken Vrij 21.1. In short, the perovskite material is the active material inside of the solar cell with a structure of ABX3, where A and B are cations, and X is an anion. In Marten's case, the perovskite functions as a LED, where a current is being supplied and converted into light. In the case of a perovskite solar cell, the workings are inverted: (sun)light is absorbed and converted into current. By changing the elemental or molecular composition and ratios of the cations and anions in the perovskite, the absorption spectrum can be tuned. A very complicated mixture of cations and anions for the perovskite was chosen to achieve an absorption which compliments the silicium bottom cell precisely. This results in an absorption of the highly energetic photons by the top perovskite cell, while the lower energetic light is passed on to the silicium. In this way more of the sunlight's spectrum can be absorbed compared to using just one cell, and therefore a higher efficiency can be reached.

The research itself is very similar to the Netherlands: the equipment, the research topics, and even the group meetings. The difference lies mostly in the rules of the institute, which are dictated by the legislation. The government is very keen on keeping everything under control, and therefore upholds strict punishments and fines for breaking the law. One of the more noticeable laws, is that you are forbidden to eat or drink inside the metro/train system. Failing to do so results in fines up to 500 S$, which equals about 330 euros. Even more severe fines can be expected for smoking at a station, up to one thousand S$. As a result, the people will abide the rules, and the streets of Singapore are safe and clean. A downside, in my opinion, is the great amount of bureaucracy that follows. Many weeks of filling in forms are required to get a working permit in Singapore, and the same holds for gaining access to research labs.

Life in Singapore is very modern, but also heavily influenced by a multitude of Asian cultures. The majority of the residents have a Chinese background, while another large part is Indian and Malay. This fact is recognizable when travelling around the many neighbhourhoods where the people come together, e.g. Little India and China Town. You will probably not be surprised to hear that there are four official languages, which include Mandarin, Malay, Tamil (Indian) and English. Most of the people are bilangual, making communicating with most relatively easy. This comes into use when ordering lunch or dinner at one of the many food courts. These places are generally an indoor plaza or common area within a facility that is filled with counters of multiple food vendors, and are very common in Singapore. You will most likely always eat noodles or rice, but do not worry, as the variety of cuisines is huge. Korean, Japanese, Thai, Chinese, Malay, Indian food, you name an Asian cuisine, and they likely have their own counter. Eating out at one of these courts is also cheap, especially compared to the supermarket. Costs are usually around 5 S$, about 3,30€.

I lived on the west side of Singapore, near the Nanyang Technological University. Housing was rented from Airbnb, and isn't cheap, due to the lack of land. About 6 million people live in 720 squared km. If I wanted to go for a drink there were plenty of bars and amazing rooftop bars in the city centre. Reaching this was also made easy by the near perfect metro/train system. Many metro and bus lines are connected and go every few minutes, and besides that are very cheap. I haven't paid more than 2,50S$ for a single trip, which include over one hour trips all the way to the east. The only detail you had to pay attention to is the fact that the people drive on the left side of

Little India

the road because of the old English roots. Unfortunately, once you reach the bar you realize that the price of the alcohol is extremely high due to the taxes and import. “Cheap” beers of 10 S$ (more than 6€) are quite common, and needless to say, if your alcohol consumption wont go down, your wallet will.

For many this will be a disappointment, and I do not want to end on a down note, so lets talk about the weather. Sunshine? Check. 30 degrees Celsius all year around? Check. No winter? Check. A lot of rain and high humidity? Check. Luckily every building and public transport has airconditioning, so do not worry about the last part. If you want to escape the winter, this is a great place to go.

Finally I would like to end by saying that living and studying abroad for an extended period of time brings more than just academical experience. Meeting new people from a variety of cultures and religions is unique and can especially be found in Singapore. I befriended people with roots in China, Italy, and of course Singapore, which gave me a much broader view on life, and which has been a great personal enrichment. I advise everybody a similar experience by living abroad, and if there any questions concerning a travel abroad or Singapore, feel free to ask.

Comic

By Kathinka Frieswijk

RESOLUTION

Resolution of the Universe

By Jasper Pluijmers

Before I start, I want you to think about the following idea: It is not unthinkable that we as humanity at some point can simulate a new universe. If we start with some nice initial conditions similar to ours, then somewhere in that simulated universe a new civilization is born. After a certain amount of time this civilization starts fooling around with computers and before we know it they have made their own similar simulation of a whole new universe! The civilization in our simulation then starts waiting on their simulation wherein a third civilization develops and they also start on their simulation. Now you are probably seeing where I am going, it is simulations all the way down. It is quite arrogant to think that we are the first civilization in this chain of infinite simulations and way more probable that we are somewhere down the line.

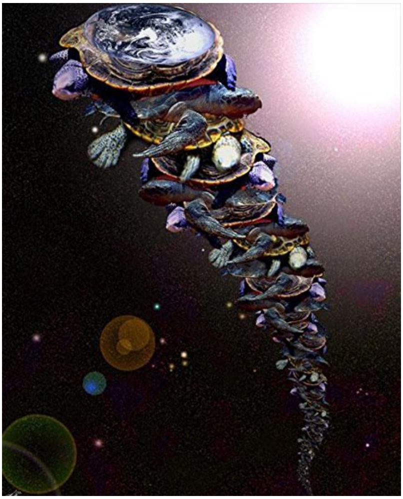


Figure 2: Simulations all the way down.

Contrary to what you may believe, the idea that our reality is not the 'real deal' is not a new concept. A very long time ago Plato posed that we see only appearances, or in his story 'the shadows in the cave'. Because all we know and observe are these appearances, we do not know the real world which is causing them. In the 17th century, Descartes also described how the whole world could be an illusion made up by an 'evil spirit'. It is not possible for us to know if what we see is real or if we are living in a dream-like state and are making everything up. As you can see, philosophers have been thinking about this for a long time, but more recently with the rise of computer technology, simulations have actually become a big thing, and we are coming closer and closer to good simulations. Every year we see simulations becoming better, both in scientific use and for consumers. Games, CGI in movies and soon the virtual reality experiences all pull us closer to a simulated reality.

Living in a simulation has been a part of pop culture for a long time now and each instance has its own clues and hints from which it is possible to deduce that reality is in fact a simulation. For example, in the popular movie series 'The Matrix' a déjà vu is experienced when something goes wrong in the simulation. 'Doctor Who' tackled this problem by bad random number generations: in certain simulations every random sequence you try to think of is the same one, showing the shortcomings of the computer simulating it.
In our universe there are also some clues that could point to simulated reality. For

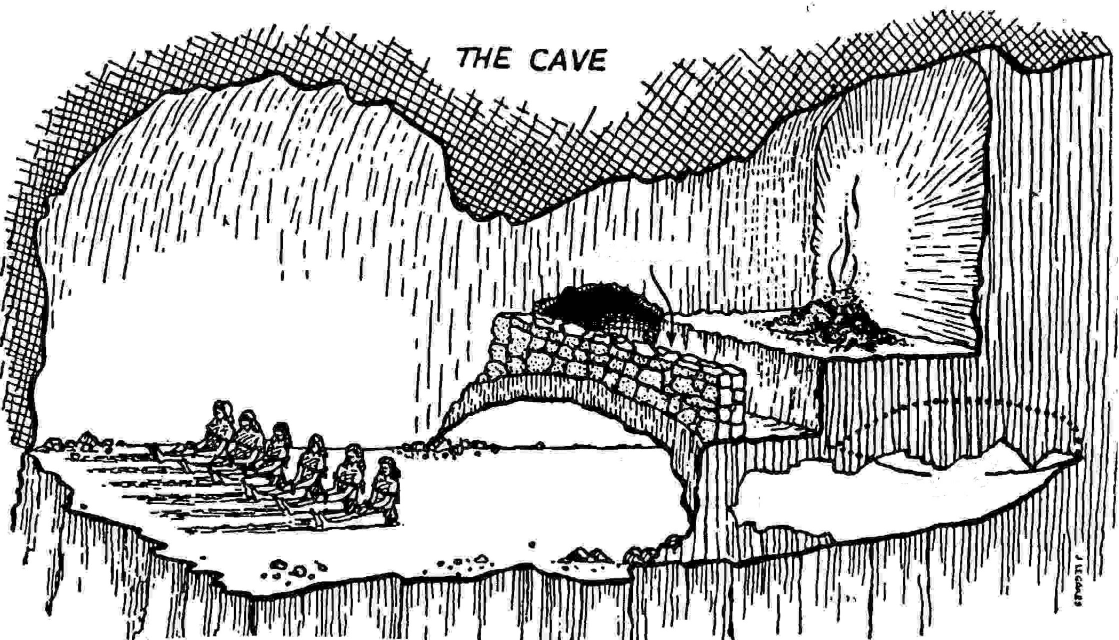
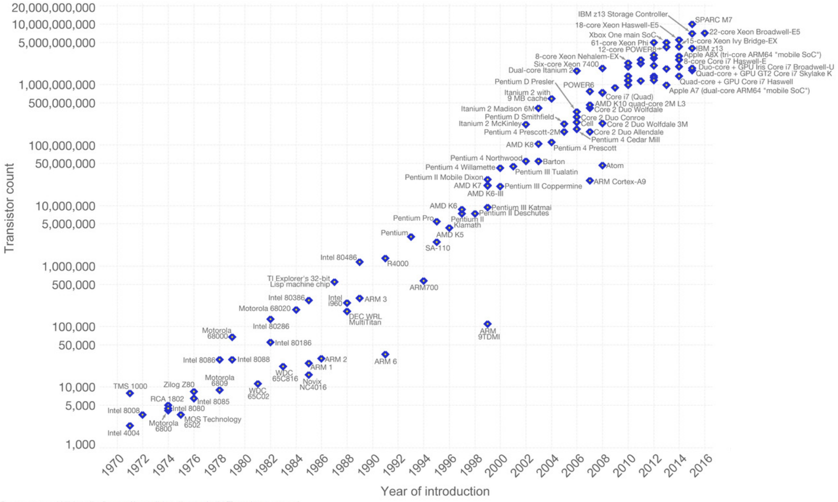


Figure 2: Plato's cave.



Moore's Law – The number of transistors on integrated circuit chips (1971-2016)

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important as other aspects of technological progress – such as processing speed or the price of electronic products – are strongly linked to Moore's law.

example, the intrinsic limits to our universe. The most famous example most of you have worked with, the speed of light. To parents who are reading this because their children did not yet change the address to their new home in Groningen: Nothing can ever go faster than the speed of light whatsoever. Which intuitively feels very strange, but some could argue that this is to limit processing power needed for the simulation. In similar thoughts, scientists have been trying to prove that spacetime is a discrete lattice, again pointing to a numerical simulation. The researchers try to look at what would happen if you do calculations of theories on such a discrete lattice and try to look if it causes observable variations from a continuous theory. Mostly this comes down to the breaking of symmetry with discrete spacetime, with the most famous example given by the Lorentz Symmetry. So far they have not found any results, but with the improvement of our calculation methods and observation techniques this could change in the future [arXiv:1210.1847v2]. (Discrete spacetime also solves all Zeno paradoxes! – Steven)

But of course these limits are not the only strange phenomena. A good way to save some processing power would be to only calculate the exact properties of particles if they are interacting. Whenever they do not it can just give them some approximate properties. This is of course part of how quantum mechanics works, a particle can be in multiple states at once until interacted with.

The biggest problem with these kind of theories is that they cannot be disproven.

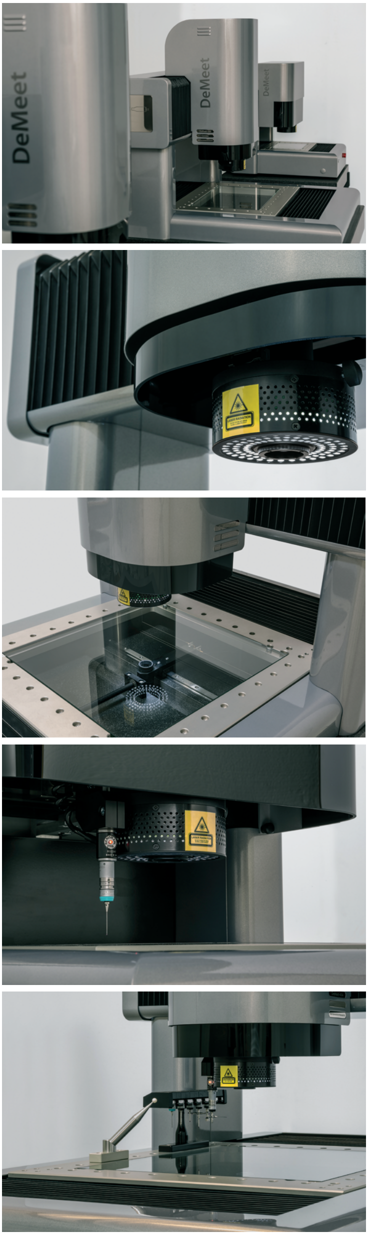
Other scientists have tried to calculate if it is actually possible to make such a computer that would be strong enough to simulate a universe [arXiv:1210.1847]. While Moore's law has been holding up for some time now, at some point physical limits will put a stop to it. Another thing to consider is that our universe is seemingly infinite, or at least we have not found any proof that it is not. And simulating something infinite seems quite hard.

The biggest problem with these kind of theories is that they cannot be disproven. In a good enough simulation we cannot not distinguish it from reality and therefore can never truly know if it is a simulation or not. One could then argue that this simulation is what we would consider the reality and thinking about something more than that reality is actually nonsense as it would change nothing and provide no observable results. Physics, for example, would stay exactly as interesting as before, we would still want to find the laws of physics in this simulation. Maybe the real question is if living in a simulation is intrinsically different from not living in one, but to find an answer to this we should look back at the philosophers.

Coming back to the intro, in 2003 Nick Bostrom published a paper 'Are we living in a Computer Simulation?' in which he argues that one of the following three statements is true:
(1) the human species is very likely to become extinct before reaching a 'posthuman' stage;
(2) any posthuman civilization is extremely unlikely to run a significant number of simulations of its evolutionary history (or variations thereof);
(3) we are almost certainly living in a computer simulation.

Two of these answers make me incredibly sad. Extinction of the human race is something I deliberately want to avoid where possible and not being able to run simulations of our own evolutionary history would be incredibly disappointing. For me this means I really hope (3) is true, although for some of you the fact of living in a simulation might spark more questions than it answers.

PHILIPS



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.

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