KAVLI NEWSLETTER

Kavli Institute of Nanoscience Delft

No. 11

October 2014

IN THIS ISSUE:

Kavli Colloquium Seth Lloyd • Kavli day 2014 • Kavli Prizes

A wave of high-profile papers

Ronald Hanson with his article on teleportation in The New York Times

Over the summer, our Kavli Institute published a remarkable high number (9) of papers in high-impact journals. The Science paper of Hanson's group on quantum teleportation attracted a lot of international attention, including two articles in the New York Times (see picture). Akira Endo published in Nature on the first observations of molecular gas and dust explosions in galaxies (the biggest explosions in the universe). The Molecular Electronics and Devices research group published 5 articles in Science and Nature-family papers. Furthermore there was a Nature Nanotechnology article of the group of Lieven Vandersypen about the electrical control of a long-live spin qubit, and a paper on cytoskeletal coordination in Nature Communications by Marileen Dogterom's group. Read more about all of these papers on page 10/11.

IN THIS NEWSLETTER

A pretty packed newsletter again this time! As you can see at the front page, there was a wave of new papers in high-profile journals, more on that on page 10/11.

On November 6, we will host Seth Lloyd from MIT as our Kavli Colloquium speaker. Seth is a remarkable scientist with a broad interest ranging from quantum physics to philosophical discussion on free will (a subject on which he recently published an essay). He has performed seminal work in the fields of quantum computation and quantum communications, including proposing the first technologically feasible design for a quantum computer, proving quantum analogs of Shannon's noisy channel theorem, and designing novel methods for quantum error correction and noise reduction. In his Kavli Colloquium, Seth Lloyd will focus on quantum phenomena in biology, a subject of obvious relevance to all of us in the Institute, see page 3 of this newsletter.

This newsletter furthermore features self-interviews by new faculty members Hyun Youk and Simon Gröblacher, columns by Bojk Berghuis and Miriam Blaauboer, and lots of news. So, enjoy!

• Cees Dekker

COLUMN

Peer review on ArXiv

Being a scientist means being a referee. Peer review is a task that is normally fulfilled individually and anonymously – you critically read the paper, do the required background research and write a report. Peer review is also subject to limited scrutiny and, in spite of the American Physical Society having introduced the "Outstanding Referees" program, in general comes with little freedom and little credit for the referee.

I wondered how this could be improved. Here is an idea for making a start.

ArXiv opens peer review. Everyone with an ArXiv account is a referee, with the obligation to review a minimum of x and a maximum of y papers per year (x and y may depend on academic position, number of years active on ArXiv etc., and are set such that the amount of expected reports is a few times the amount of expected papers over a certain period). Referees are free to choose which papers they review and ArXiv introduces an additional line upon submission in which authors can "advertise" their paper to potential referees.

A review round proceeds as follows after submission of a paper, the ArXiv server collects reports during a limited time interval. At the end of this period all reports received are sent to the authors who, again within a certain period, have the opportunity to comment on each of them. The reports, the author's comments and the revised manuscript are then published on ArXiv. Unless they object, referees' names appear on their reports.

I think there would be many advantages to this type of open peer review. For authors, knowing the identity of their referees will make the review process more transparent and the direct communication with them is likely to lead to interesting open access scientific discussions. Reviewers can publicly distinguish themselves as high-quality referees (soon, a new index will be invented quantifying ArXiv reviewers' abilities). Readers will benefit from having additional information on each paper and journals are free to use the reports submitted to ArXiv. For the scientific community as a whole, review on ArXiv will likely reduce the power of editorial boards.

But… isn't there a danger that some referees will only review their friends' papers? Or that referees will be reluctant to be too critical, in order to save friendships? How do we deal with belligerent referees that write disrespectful reviews? And what about the additional technical challenges for the ArXiv infrastructure?

Sure enough, all these challenges can be solved: the upper limit of y reports per referee forms a barrier against excessive favouring of friends. In addition, the referee's relation to the authors could be published alongside his/her name. Extending the ArXiv infrastructure does not require anything that does not yet exist in other sectors. And as for outrageously belligerent referees – authors could for example be given the right to request their identity being made public under certain conditions.

I am convinced that the advantages of open peer review will outweigh the possible drawbacks. It is time for introducing preprint review and creating more freedom and credit for referees.

• **Miriam Blaauboer**

INTERVIEW

Interview with Seth Lloyd

Dr. Seth Lloyd is a Professor at Massachusetts Institute of Technology and principal investigator at the Research Laboratory of Electronics and is one of the directors of W.M. Keck Foundation Center for Extreme Quantum Information Theory (xQIT). He is known for his seminal work on quantum computation and proposed the first technologically feasible design of a quantum computer.

Can a quantum computer ever be developed to compute?

Yes. Quantum computers process information using atoms, photons, superconducting circuits, and other systems that obey the laws of quantum mechanics. Entropy is a form of information – information that we do not possess about the motions of atoms and elementary particles. Entropy is unknown information. Quantum computers can be used to detect and process this unknown information. A single electron in an unknown state of spin possesses one bit of entropy. This electron spin can be thought of as a random quantum bit that can be used as the input for a quantum computer, which then responds to and processes this bit of entropy.

Is it plausible to equate and quantitate information with entropy and degrees of freedom?

Indeed. One can even say that Maxwell and Boltzmann, in their efforts to quantify entropy in the nineteenth century, showed the equality between entropy and information. Like the electron spin from the previous paragraph, every degree of freedom of a physical system registers information: if we don't know the state of that degree of freedom, then that information counts as entropy and enters into the second law of thermodynamics.

It is said that quantum computing takes us closer to the way nature computes, but has the scientific community defined exactly how nature processes information?

Quantum computers are of course physical devices that might be used to factor numbers and to break codes, but they also allow us to understand how nature processes information at a fundamental level. Every atom or elementary particle carries with it bits of information. Every time two particles collide, those bits flip. Quantum information processing makes precise the way in which quanta register information and shows how that information is processed. The strange and counter-intuitive nature of quantum mechanics shows that, at the bottom, nature processes information in a strange and counterintuitive fashion: it is this `quantum weirdness' of information processing that leads to the potential power of quantum computation.

Would you have another debate with David Deutsch (in one of the parallel worlds at least), and if yes what would be the bone of contention?!

I always enjoy debating with David. In the end, our debate on the existence of parallel worlds resulted in our coming – almost – to agreement. The only difference that remains is that David regards the other `worlds' in the many-worlds theory of quantum mechanics as being equally real to our own world. Since I regard reality as having empirical content, I disagree: the other worlds in many-worlds quantum mechanics are exactly the parts of the quantum wave function to which we have NO empirical access. So our world is the only one that is empirically real.

How did it feel to be the deliverer of Feynman's vision on the Universal Quantum Simulator?

The history of how I came up with the first quantum algorithm for quantum simulation is as follows. I had read Feynman's paper when it first came out, and found it to be entertaining and impressive. A decade later, when I began teaching at MIT, the first course I taught was a control theory laboratory in which we used analog computers. I began wondering what a quantum analog computer would look like. In his paper, Feynman stated that it seemed implausible that one could build such a device. By 1994, however, we were already working on the first simple quantum information processors. I realized that we could use these quantum information processors in a digital fashion to realize Feynman's analog dream. Subsequently, Dave Cory and I constructed the first quantum simulators. It felt good.

What in your opinion drives humanity to discover the limits of the universe?

We inhabit the universe, after all, and it makes sense to explore our home. Of course, it would be nice to know why the universe exists, and why we are here to inhabit it. Philosophy asks 'Why?', Science asks 'How?' A pleasing aspect of science is that sometimes the answer to 'How' leads to an answer to 'Why'. For example, we ask, Why does the universe exhibit such a degree of intricacy and complexity? When we study how quantum mechanics operates we find that the digital nature of quantum mechanics

KAVLI COLLOQUIUM

'Quantum life'

Seth Lloyd

Massachusetts Institute of Technology

November 6, 2014 will feature a Kavli colloquium by Seth Lloyd.

The abstract of this colloquium reads as follows: Nature is the great nanotechnologist: life is based on a myriad of interlinked mechanisms that operate at the molecular scale. The dynamics of these mechanisms are governed by quantum mechanics. Quantum mechanics famously exhibits strange and counterintuitive effects based on quantum coherence and entanglement. Does such `quantum weirdness' play a role in the functioning of living systems? Recent experimental investigations of photosynthesis indicate that quantum coherence may play an important role in optimizing energy transport in photosynthetic complexes. This talk presents a general theory that shows how quantum coherence can dramatically enhance energy transport in photosynthesis and in artificial systems. Optimal energy transport takes place at the point where the timescales for dynamic and static disorder converge, a phenomenon called the quantum Goldilocks effect.

Seth Lloyd

15.00 h	Pre-programme on the Nobel prizes
	The 2014 Nobel prize in medicine explained by Christian Doeller The 2014 Nobel prize in physics explained by Carlo Beenakker The 2014 Nobel prize in chemistry explained by Nynke Dekker
15.45 h	Break
16.00 h	Kavli colloquium by Seth Lloyd: 'Quantum life'
17.15 h	Drinks & time to meet

EXTRA SEMINAR

'Quantum machine learning algorithms'

On November 7, 2014 Seth Lloyd will additionally present a lecture on: 'Quantum machine learning algorithms'. The abstract for this lecture reads as follows: Machine learning algorithms look for patterns in large arrays of high-dimensional vectors. Quantum computers are adept at manipulating large arrays of high-dimensional vectors. This talk presents a series of quantum algorithms for big data analysis. The ability of quantum computers to perform Fourier transforms, find eigenvectors and eigenvalues, and invert matrices translates into quantum algorithms that are exponentially faster than their classical counterparts: complex patterns in datasets of size N can be identified in time O(log N).

KAVLI COLLOQUIUM

'Quantum life'

Date: November 6, 2014 at 15.00 hours

Location: Aula, Lecture room D

EXTRA SEMINAR

'Quantum machine learning algorithms'

Date: November 7, 2014 at 10.00 hours

Location: Faculty of Applied Physics, Lecture room E

leads to a digital nature to chemistry – there are only a countable number of different stable molecules – which leads to the digital nature of the genetic code. When we study how quantum computing works, we find that all molecules register and process information, and that the essentially computational nature of the universe makes it highly probable that this chemical information processing should lead to complex structures such as life.

• Nandini Muthusubramanian

Transformative contributions to the field of nano-optics

Our ability to manipulate and shape light has driven scientific and technical advancements for hundreds of years, from van Leeuwenhoek's microscopes to the communications revolution made possible by the laser.

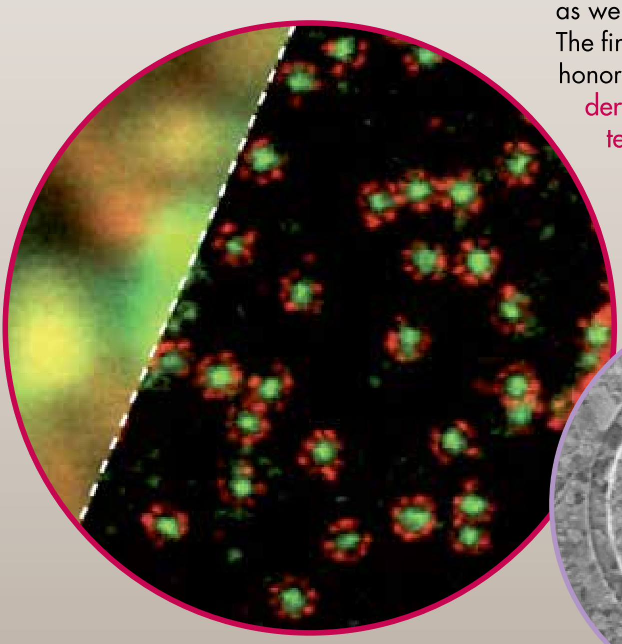
His Majesty King Harald of Norway presents the 2014 Kavli Prize in Nanoscience. Left to right: Thomas W. Ebbesen, Stefan W. Hell, Sir John B. Pendry, and HRH King Harald. (Credit: Scanpix)

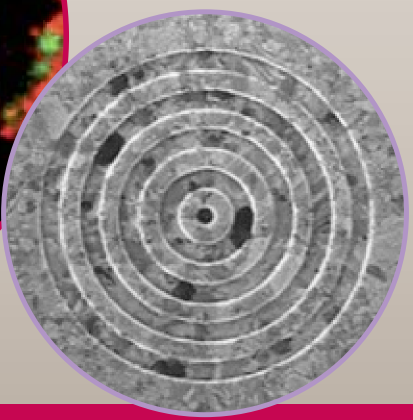
Unfortunately, the limitations of light are all too familiar to those of us at the Kavli Institute at TU Delft. Whether we wish we could generate smaller features in the clean room or observe cells with more detail in the laboratory, the wavelength of light poses fundamental limits on what we are capable of. This year's Kavli Prize in Nanoscience recognized three researchers "for their transformative contributions to the field of nano-optics that have broken long-held beliefs about the limitations of the resolution limits of optical microscopy and imaging."

Thomas Ebbesen was recognized "for the discovery of the extraordinary transmission of light through sub-wavelength apertures." In far field microscopy, we can only observe features down to roughly the wavelength of light. In near field microscopy, evanescent waves can follow features much smaller than this. In a typical near field microscope, these evanescent waves are generated by shining light through tiny apertures. The smaller the aperture, the better the resolution but this comes at the cost of fewer transmitted photons. Ebbesen's unexpected but welcome finding was that more photons could be collected by these apertures than the established theory of the time predicted. Thanks to interactions with surface plasmons, an aperture can transmit more light at certain resonant peaks. Thanks to these resonances, a smaller aperture can sometimes let more light through than a larger one. We now can model this "extraordinary" transmission and design apertures that shape and filter light in surprising ways for optical detection and photonic circuits.

The second recipient of the prize, **Stefan Hell** (Nobel laureate), was acknowledged for "for ground-breaking developments that have led to fluorescence microscopy with nanometre scale resolution, opening up nanoscale imaging to biological applications." As mentioned earlier, we can only observe features on the order of the wavelength of light in the far field. However, Hell realized that you could take advantage of the nonlinear response of fluorescent probes and a clever pattern on excitation to reconstruct higher resolution images. Briefly, Hell uses a pair of lasers: one to excite fluorescent dyes and then a second to quickly deplete these excited dyes by stimulated emission. This technique, labeled Stimulated Emission Depletion (STED) by Hell, is nonlinear so a pattern that leaves a small area excluded from the depletion can probe the dyes in an arbitrarily small volume in space. Hell has commercialized the STED microscope and demonstrated its abilities to measure tiny features in biological samples. Together with a related group of super-resolution microscopy techniques, STED is opening new windows into the workings of the cell. Hell's research group continues to push the boundaries of these techniques as well.

The final recipient, **John Pendry**, was honored "for developing the theory underlying new optical nanoscale materials with unprecedented properties, such as the negative index of refraction, allowing for the formation of 'perfect lenses'."





The refractive index typically defines the degree to which light is slowed down by a medium, so a negative refractive index implies light would travel backwards upon entering the new medium. This may seem odd, but such materials had been shown to be perfectly consistent with electromagnetic theory long before anyone had observed the phenomenon in the real world. In fact, the possibility of creating a negative index of refraction was largely forgotten when Pendry predicted how one might go about constructing a negative index meta-material. His theories were confirmed by experimentalists soon after. Furthermore, Pendry has devised several ingenious applications for these materials that sound like far fetched science fiction, such as perfect lenses that can reconstruct an image not limited by the wavelength of light or a "cloak of invisibility" that could completely mask an item from detection. The main barriers to realizing these devices lie in the difficulty of designing and manufacturing negative index materials (particularly in the visible range), but many groups are making progress on that front. Pendry and David Smith demonstrated cloaking at microwave frequencies in 2006, and "superlenses" made of silver have been described that can reconstruct some of the evanescent waves from a sample.

Just as van Leeuwenhoek's microscopes inspired other scientists to explore the world of microbiology, each of these discoveries has inspired research groups around the world to pursue further discoveries using light. Already, the applications of the insights described above have benefited a wide range of fields from physics to chemistry to biological sciences. It will be exciting to follow where these areas of research lead us in the next decade.

• Elio Abbondanzieri

Amazed by the dynamics of the different research groups

A little more than 10 years ago, after a small detour into astronomy, I made my way into physics. Even though it came with quite a few ups and downs I'm still very excited about it, and here I am now, about to start my own research group in Delft. Who would have thought? Certainly not me! I like challenges and change, which resulted in me moving abroad several times throughout the years – the Netherlands will be my 5th try at calling a new place home. I did most of my undergrad and graduate studies in Vienna, where I learned to love quantum physics and became really passionate about quantum optomechanics. In this relatively new field, people try to make mechanical systems behave according to quantum physics. In the approach that I used and will also use in my future research, this is done with light, hence optomechanics. The ultimate goal, at least from my point of view, is to use these systems to probe macroscopic quantum effects. This is still very hard and quite a few years away, but we're getting there!

When I first came to the Kavli Institute in Delft I was amazed by the dynamics of the different research groups and the institute as a whole – joint meetings, a seemingly very friendly atmosphere, almost like a family, and collaborations everywhere I looked. It all made it very appealing to me. And all of this interleaved with top-notch research groups and facilities. At the time of that visit, I was close to finishing my postdoc at Caltech (interestingly partly also a Kavli Institute), and after spending a few days in Delft, I very quickly realized that this was the ideal place for starting my own group.

I envision that the hardest part in adapting to this new environment will be that I'll have to actually think about what to wear in the morning when I get out of bed – living in Southern California really spoiled me. Hopefully this will also not affect my excercising routine – I try to swim and/or run every day. Wait, maybe I'll actually be able to combine this in the Netherlands?! Besides the sports, what keeps me sane and let's me unwind from physics is traveling, which I fortunately have been doing excessively, eat good food, and cheerish time with my friends.

There is one slightly more unusual hobby I have, which once you get to know me, starts making a lot of sense – I try to go to this thing called 'Burning Man' in Nevada once a year. If you don't know what that is – come and ask me. Also if you've heard something about it, come and I'll tell you what it's not. For me it's the perfect getaway, once a year being completely disconnected from society for a week.

Let me conclude this little bit of public self-reflection by saying that I am very much looking forward to starting at the Kavli Institute and hope that this is the beginning to some very productive and exciting years.

• **Simon Gröblacher**

NEWS

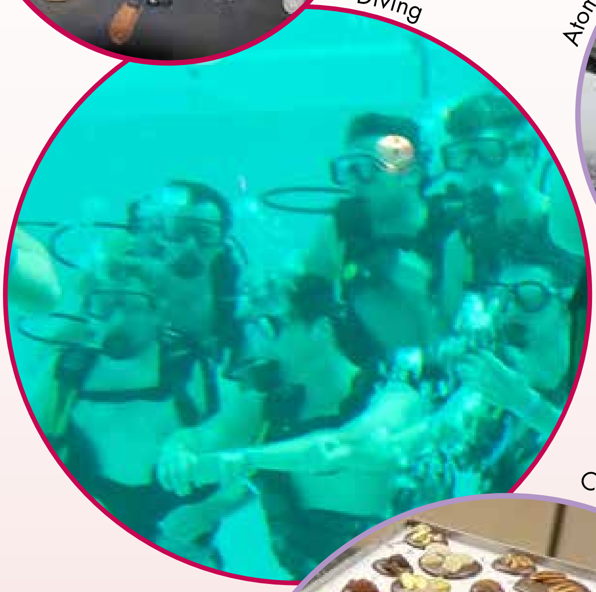
Football Match Kavli Institute Delft versus MPQ Garching

In June, we had the second joint workshop on quantum information science between the Max Planck Institute for Quantum Optics in Garching, Germany, and the Kavli Institute of Nanoscience Delft. It was a good mix, with inspiring scientific discussions … and a fun soccer game (though we lost). Practice has started for the next game, this time to be held in Delft.

An inspiring day in Brussels


Cartoon drawing workshop


Visit to the European Parliament


Diving


Atomium


Lecture by George Whitesides


Chocolate workshop


Beer tasting


Jogging in Brussels

'Do research that makes a difference to the world'

George Whitesides, director of the Kavli Institute for Bionano Science & Technology at Harvard and the most-cited living chemist in the world, opened the Kavli Day with an inspiring talk in one of the nine atomic spheres of the iron-crystal-shaped Atomium in Brussels.

Whitesides started off by saying that this talk would be different from the usual 'these-are-my-latest-scientific-results'-type seminars. In his talk he advocated use-inspired basic research with sixmplicity at its core. He explained in some detail how his research team in Harvard developed new diagnostic systems based on simple paper. These combine the complex science of microfluidics with the simple process of ink jet printing for easy and low-cost detection of early signs of diseases.

In practice, it appears to be difficult to bring such very low cost technologies to the market as in our world 'diseases that are treated, are those that are profitable'. Therefore Whitesides and his colleagues additionally set-up the non-profit enterprise Diagnostics For All's (DFA, www.dfa.org). The mission of this enterprise is to save lives through the creation of low-cost, easy-to-use, point-of-care diagnostic devices designed specifically for the developing world. These simple technologies can lead to high-tech methods, which on second thoughts also appear to be of interest to the Western world, the so-called 'reverse innovation'.

The presentation by Whitesides led to much interest and discussion among the members of our Kavli Institute, providing the food for thought that these colloquia are meant for.

• **Jennifer Kockx**

2014 Kavli Delft publication prize

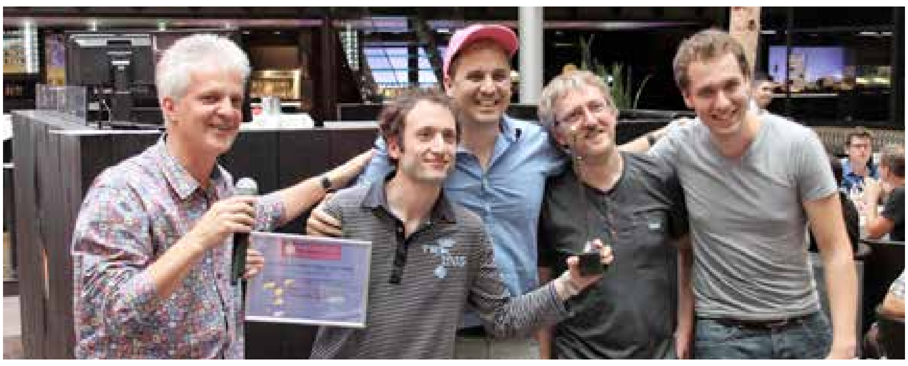
On our Kavli Day 2014, the 2014 Kavli Delft publication prize was awarded. This is a prize for the best publication that has resulted from our Kavli Institute that appeared in print in the previous two years. This prize, which consists of an award and an amount of € 3000 for the laureates, is given out every two years. Various nominations had come in. A selection committee consisting of 4 senior and junior professors from our Institute read the papers that were sent in and ranked them. The selection committee had a hard task because of the good quality of many of the papers that were sent in,but in the end, the committee reached a verdict and selected the winning paper.

The 2014 Kavli Delft publication prize was awarded to Diego Riste, Marcin Dukalski, Christopher Watson, Gijs de Lange, Marijn Tiggelman, Yaroslav Blanter, Konrad Lehnert, Raymond, Schouten and Leo DiCarlo, for their paper "Deterministic entanglement of superconducting qubits by parity measurement and feedback" that appeared in Nature in October 2013.

This paper reported the first solid-state realisation of two key ingredients for error correction in a quantum processor, namely non-destructive qubit parity measurement and feedback control based on its results. These ingredients were combined for the first time in any approach to produce entanglement on demand.

Several highlights make this paper a worthy prize winner: The experiment has been recognized as a tour de force by the quantum computing community and the paper is highly cited by papers from very diverse fields. The work nicely exemplifies the collaborative spirit of our Kavli Institute, with, next to the core experimentalist, key contributions from theorists Dukalski and Blanter, electronic engineers Tiggelman and Schouten and Casimir student C. A. Watson. The work was made possible by the excellent infrastructure available at our institute at the Kavli Nanolab, and building on equipment passed on by the group of Hans Mooij. It is also wonderful that the work was led by one of our younger PIs, Leo diCarlo, who established this success within three years of the start of his research group.

Finally, for those of you that like to grasp the content of the paper quickly: the authors made some great and funny English and Dutch movies to explain the result to non-specialists, movies that have been viewed more than 5000 times on YouTube, see www.youtube.com/watch?v=TzELhI6YWfI.



ORGANISATIONAL SHIFTS

Cees Dekker has been reappointed for 4 years as Director of our Kavli Institute.

New members have been appointed in the Kavli Advisory Committee which advises the director for Kavli Colloquium speakers, Delft prize awards, and other Kavli business. Nynke Dekker and Sander Otte will now leave the committee after doing this in the past years and we thank them for their contributions. They are succeeded by Anton Akhmerov and Marileen Dogterom. Chirlmin Joo and Herre van der Zant will continue their membership.

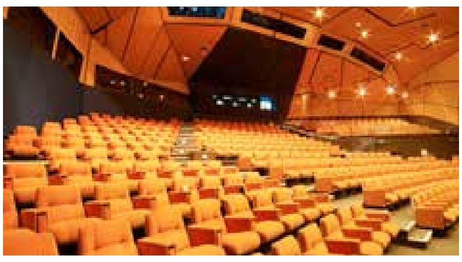
NEW EMPLOYEES

Name	Date of employment	Title	Lab
Yang Zhou	01/06/14	Postdoc	QN/TN
Jason Mensingh	15/06/14	Technicus	QN/QT
Heleen Woldhuis	19/06/14	Management Assistant	QN
Tino Kool	01/07/14	Technicus	QN/MED
Sumit Deb Roy	01/07/14	PhD	BN/ Nynke Dekker lab
Thibaut Jullien	01/07/14	Postdoc	QN/QT
Alex Proutski	01/08/14	PhD	QN/QT
Norbert Kalb	01/08/14	PhD	QN/QT
Hao Zhang	01/08/14	Postdoc	QN/QT
Nima Kalhor	15/08/14	Postdoc	QN/KN
Suzanne van Dam	01/09/14	PhD	QN/QT
Ka Shen	01/09/14	Postdoc	QN/TN
Liedewij Laan	01/10/14	Assistant Professor	BN/ Liedewij Laan lab
Fokko de Vries	01/10/14	PhD	QN/QT
Ali Elshaari	01/10/14	Postdoc	QN/QT
Lily Yang	01/10/14	Postdoc	QN/QT
Robin Dolleman	01/10/14	PhD	QN/MED
Roy de Leeuw	15/10/14	PhD	BN/ Nynke Dekker lab
Takafumi Fujita	01/11/14	Postdoc	QN/QT
Doru Sticlet	01/11/14	Postdoc	QN/TN
Adriaan Vuik	01/11/14	PhD	QN/TN
Joao Pereira Machado	01/11/14	PhD	QN/TN
Richard Norte	01/11/14	PD	QN/MED
Simon Gröblacher	01/11/14	Assistant professor	QN/MED
Samer Houri	01/11/14	PD	QN/MED
Muhammad Irfan	15/11/14	PhD	QN/TN
Behrouz Eslami	01/11/14	Postdoc	BN/ Martin Depken lab

NanoFront Winter Retreat: 16-21 March, 2015

Join us for the first edition of the NanoFront Winter Retreat in the week of 16-21 March 2015!

All PhD students, postdocs and members of the scientific staff working in our BN and QN departments are kindly invited to travel with us, together with our colleagues from LION at Leiden, to Courchevel, France, for five days of NanoFront science, lectures, workshops and poster presentations.



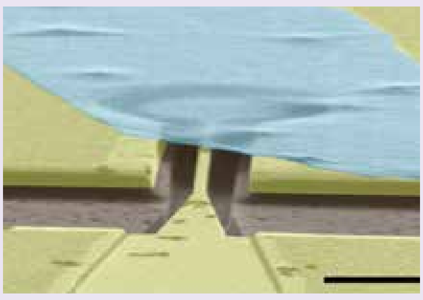
The NanoFront Winter Retreat offers an excellent opportunity to meet your fellow NanoFront researchers. During the scientific sessions in the mornings and evenings you will learn more about their recent findings on the frontiers of Quantum Nanoscience, Bionanoscience and Nanotechnology. In the afternoons, all participants are free to go skiing (at their own expense).

More information on the program and registration will soon be available on our website: www.nanofront.nl

For questions you can contact Marije Boonstra m.k.boonstra@tudelft.nl

VIDI PROJECTS

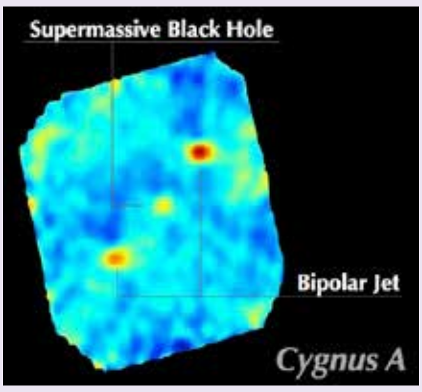
Vidi Project for Gary Steele on quantum motion of carbon mechanical resonators



A graphene drum coupled to a superconducting microwave cavity, one of the platforms Gary will use to explore quantum motion

NWO has awarded a prestigious Vidi project to Gary Steele. Gary will study quantum superpositions of physically large objects. While we are accustomed to finding atoms or qubits in quantum superpositions, the same does not hold for macroscopic objects. Understanding why we don't find cats in a superposition of being dead and alive is still an open question in quantum mechanics. In this project, Gary will explore these topics using mechanical resonators in the quantum regime. By making "Schrödinger cat" states out of mechanical membranes in which membranes are bouncing both up and bouncing down at the same time, Gary will use these mechanical "cats" to store quantum information in motion, and to explore the boundaries of macroscopic quantum mechanics.

Vidi Project for Akira Endo on Superconducting Astrophotonics



220 GHz emission from the radio galaxy Cygnus A, observed with NbTiN-based kinetic inductance detectors (KIDs) fabricated in the Van Leeuwenhoek Laboratory.

NWO has awarded a prestigious Vidi Project with the title Dawn on Superconducting Astrophotonics. Astronomy and quantum physics have a common desire to analyze the property of light at its faintest limit. In the 1950's, Hanbury Brown and Twiss observed the second-order correlation of light from stars, which heralded the birth of a new field of quantum optics. Now, Akira aims to initiate the paradigm of "superconducting astrophotonics" through this Vidi program. In a similar spirit to how circuit quantum electrodynamics has improved upon (optial) cavity quantum electrodynamics, Akira will push the limits of nanoscience and nanotechnology in order to integrate many of the functionalities of current astronomical instruments onto a chip. This new generation of instruments will be not only extremely compact, but also powerful in performance because the integration enables a greater degree of multiplexing.

Amazed by the sheer number of connections to Delft

Joining the Kavli Institute at TU Delft marks several new beginnings for me. Starting this October, I will be adjusting to a new country, a new language, a new culture, a new department, new colleagues, a new research direction and for the first time, a lab of my own. The Netherlands is my fourth country of residence. I'm a Canadian citizen and grew up in Toronto, but I was born in South Korea. My family moved to Canada when I was very young so unfortunately I have forgotten much of the Korean language, which means that there's more room for Dutch in my brain. But I still remember my first days in Canada. I didn't know any English. I remember the shock of seeing very tall people for the first time. I suppose I will repeat this experience here in the Netherlands but now with a different language and even taller people! I hope to be fluent in Dutch in a few years so that I can use Dutch for teaching undergraduates and writing moderately discomforting Sinterklaas poems.

I first became interested in TU Delft and its Applied Physics department (as it was known at the time) as an undergraduate in physics and math at the University of Toronto. Motivated by the beautiful experiments such as those of Sander Tans, Cees Dekker, Leo Kouwenhoven and Hans Mooij, just to name a few, I initially set my sights on becoming a condensed matter physicist and had a brief stint in theoretical many-body physics for my Masters degree. I then joined MIT's physics department with the intention of performing experiments on ultracold atomic systems for my PhD. But because MIT gave me a fellowship for my first year, I could explore other options. Every morning, I walked past the lab of Alexander van Oudenaarden, which was in the physics building at the time. Ironically, I initially didn't realize that Alexander had studied at Delft because I had forgotten that I read some of his papers several years before. Having never taken any biology courses in university, I couldn't even understand the titles of the papers and posters on the walls outside his lab. I also didn't know what basic equipment like pipettes looked like.

However I was struck by how happy his students appeared to be and the laughter that often emanated from his lab (a rarity in the halls of MIT physics). Soon I had my first meeting with Alexander in which I said, "I will stay unless you fire me". Thankfully he didn't fire me and I regard this switch to quantitative biology to be the greatest life-changing decision I've made as a scientist. Incidentally, my friend and housemate in Boston was a PhD student of Jing Kong, who was a postdoc in Cees Dekker's lab before she started her own lab at MIT. As I'm writing this, I'm thus amazed by the sheer number of connections to Delft that I already have.

My fascination with biology comes from its very basic conceptual questions that still remain unanswered despite all the fancy technologies we now have. As an example, what does it mean for a group of molecules to be "living"? How should they be wired together so that they produce sentient beings like you and me? If we are all gigantic molecular machines and given that some behaviors are innate in certain organisms (not learned), were we pre-programmed at birth to make the decisions of tomorrow like what we'll eat for lunch? How do "free-will" and decision-making emerge from the laws of physics? These aren't questions just for neuroscientists.

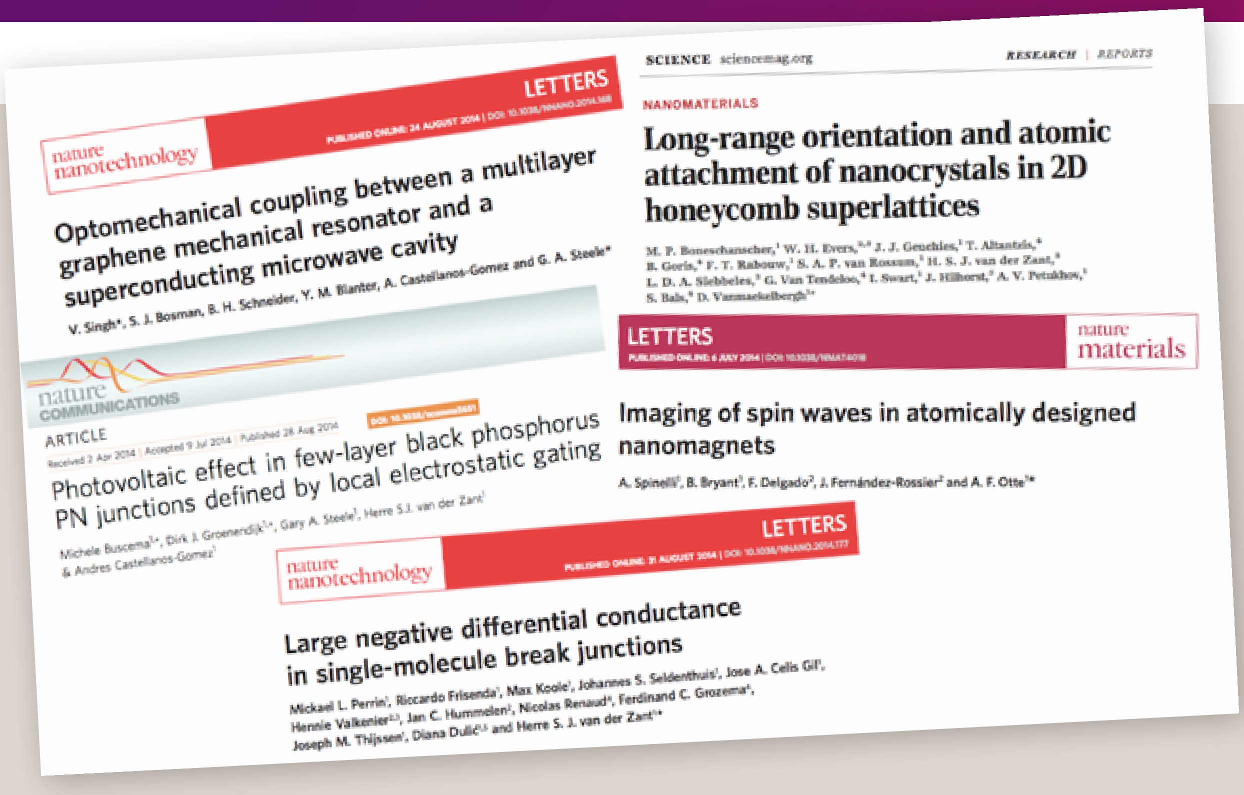
Amazingly, we can tackle the core "design principles" underlying these questions using microbes. It's increasingly becoming clear that deep understanding of living systems will require quantitative experimental and theoretical approaches of physics. The basic building blocks of life are atoms. Yet the striking success of physics in explaining non-living systems hasn't translated into explaining living systems. This is partly due to the presence of many different types of interactions in a cell, which prevents simply applying the common methods of many-body physics. My lab's aim is to combine experiments and theory to make a significant progress in meeting this challenge.

Yet the striking success of physics in explaining non-living systems hasn't translated into explaining living systems.

When I'm not in the lab, I like to run and travel. I'm also a collector of "general things" that some may call "junk". For example, I try to collect magnets, postcards, ticket stubs and receipts from all the places that I travel to for leisure and conferences. They allow me to remember what I did in the past. I also enjoy attending live music concerts, especially jazz concerts. It's too bad that I missed the Delft Jazz festival in August! But I have to admit, at the risk of sounding boring, my most enjoyable hobby is doing science.

As I spent more and more time in the United States, I increasingly looked for opportunities outside the US. The more favorable funding atmosphere and down-to-earth research culture in Europe have solidified my decision to leave the US. I was particularly happy to learn that the Delft Kavli Institute was hiring and even happier when I got hired. I'm very grateful for the opportunity to develop my lab here. I look forward to meeting all the students, postdocs, research and administrative staff during my initial months. Please drop by and say hello! I hope to pursue creative science and contribute to maintaining a friendly atmosphere of our institute for years to come.

• **Hyun Youk**


LETTERS
nature nanotechnology
Optomechanical coupling between a multilayer graphene mechanical resonator and a superconducting microwave cavity
V. Singh*, S. J. Bosman, B. H. Schneider, Y. M. Blanter, A. Castellanos-Gomez and G. A. Steele*

nature COMMUNICATIONS
ARTICLE
Photovoltaic effect in few-layer black phosphorus PN junctions defined by local electrostatic gating
Michele Buscema, Dirk J. Groenendijk, Gary A. Steele, Herre S.J. van der Zant & Andres Castellanos-Gomez

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Long-range orientation and atomic attachment of nanocrystals in 2D honeycomb superlattices

LETTERS
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Imaging of spin waves in atomically designed nanomagnets
A. Spinelli, B. Bryant, F. Delgado, J. Fernández-Rossier and A. F. Otte*

LETTERS
nature nanotechnology
Large negative differential conductance in single-molecule break junctions
Mickael L. Perrin, Riccardo Frisenda, Max Koole, Johannes S. Seldenthuis, Jose A. Celis Gil, Hennie Valkenier, Jan C. Hummelen, Nicolas Renaud, Ferdinand C. Grozema, Joseph M. Thijssen, Diana Dulić and Herre S. J. van der Zant*

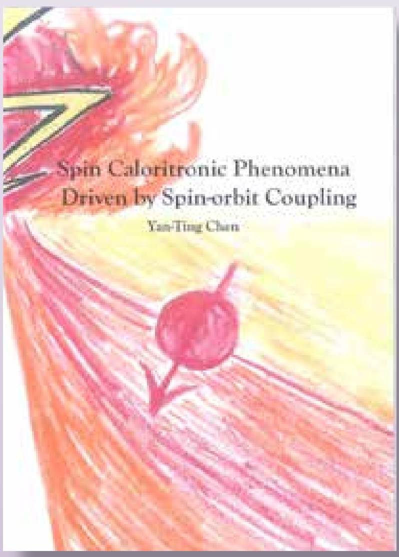
High Profile Summer for MED

The Molecular Electronics and Devices (MED) research group in QN has recently undergone a rapid expansion. Having come from just one PI in 2010, the group now boasts four independent subgroups, 10 postdocs and some 20 PhD students. It is inevitable that such a sudden growth of research efforts initially comes with a period of low returns; a time in which labs are built rather than papers written. But this summer it was time for the harvest: in less than three months MED has published five high-profile papers!

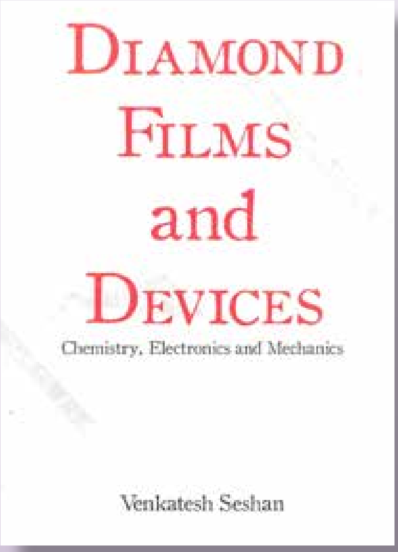
Vibhor Singh and coworkers of the Steele Lab demonstrate in Nature Nanotechnology how they coherently couple microwave photons to a graphene mechanical resonator. In the same journal, Mickael Perrin et al. (van der Zant Lab) present a surprising decrease of the current through a single molecule with increasing voltage. In Nature Materials, Anna Spinelli et al. (Otte Lab) report the first observation of spin waves on the atomic scale, while Michele Buscema et al. (van der Zant Lab) show the first steps towards building a black phosphorus solar cell in Nature Communications. Finally, Wiel Evers (van der Zant Lab) co-authored a paper in Science demonstrating beautiful new two-dimensional lattices built from synthesised nanocrystals.

V. Singh et al., Nature Nanotechnology 2014 168
M. L. Perrin et al., Nature Nanotechnology 2014 177
A. Spinelli et al., Nature Materials 13, 782 (2014)
M. Buscema et al., Nature Communications 5, 4651 (2014)
M. P. Boneschanscher et al., Science 344, 1377 (2014)

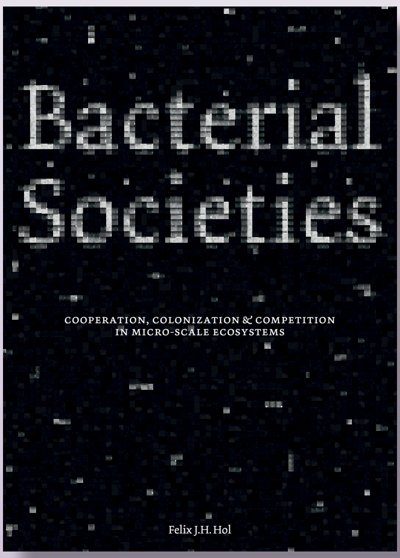
RECENT PHD THESES



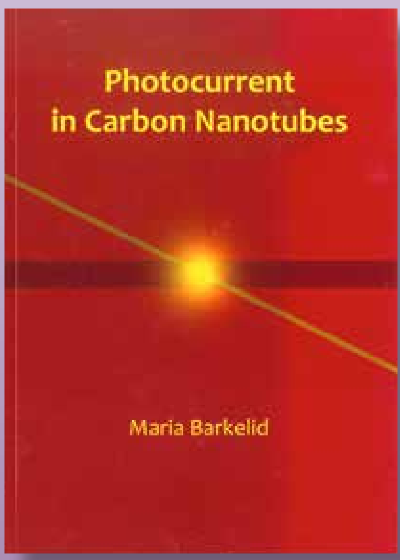
Yan-Ting Chen
2 June 2014



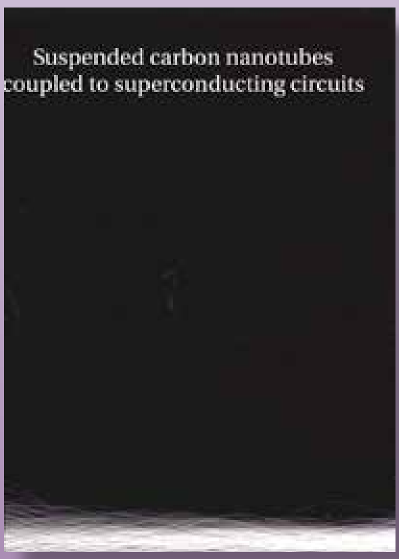
Venkatesh Seshan
20 June 2014



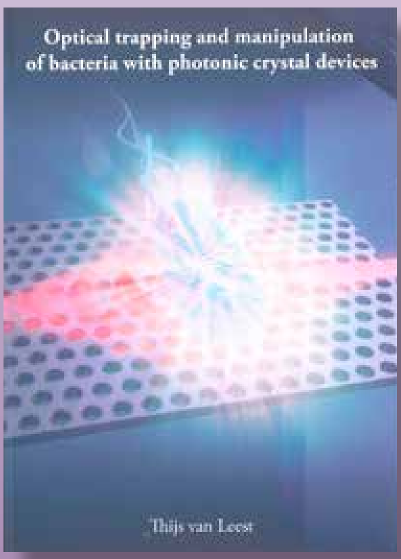
Felix J.H. Hol
20 June 2014



Maria Barkelid
2 July 2014

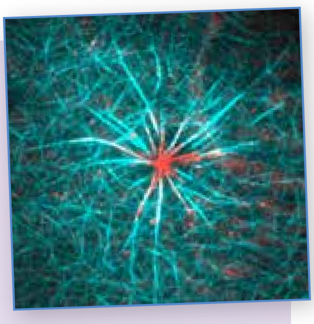


Ben Schneider
3 July 2014



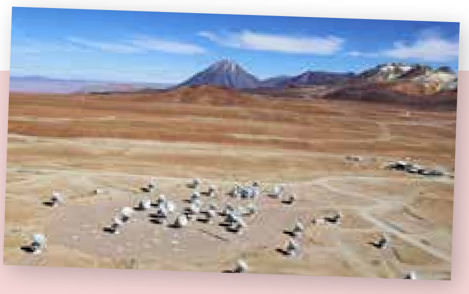
Thijs van Leest
8 September 2014

Actin-microtubule co-ordination at growing microtubule ends



Living cells rely on a properly organized cytoskeleton to power processes such as growth and division. Even though individual cytoskeletal polymers such as microtubules and actin filaments have been studied for decades, it is unknown how these systems coordinate their spatial organization. We engineered an artificial protein capable of binding both actin filaments and growing microtubule ends. We demonstrated that stiff actin bundles dictate the organization of growing microtubules, whereas growing microtubules dictate the organization of single actin filaments. Mechanical interactions between actin filaments and microtubules thus lead to a variety of biologically relevant cytoskeletal organizations, with just the help of a simple cross-linker.

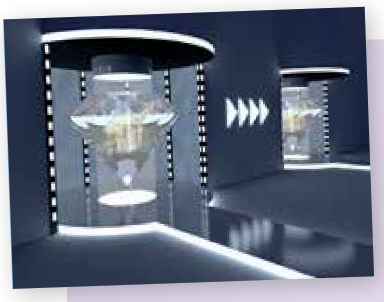
M. Preciado López, F. Huber, I. Grigoriev, M.O. Steinmetz, A. Akhmanova, G.H. Koenderink, M. Dogterom. Nature Communications, August 2014



"Two gamma-ray bursts from dusty regions with little molecular gas,"

Observations from the Atacama Large Millimeter/submillimeter Array (ALMA) have for the first time directly mapped out the molecular gas and dust in the host galaxies of gamma-ray bursts (GRBs) — the biggest explosions in the Universe. In a complete surprise, less gas was observed than expected, and correspondingly much more dust, making some GRBs appear as "dark GRBs". Researchers from the CosmoNanoscience group have contributed to both the astronomical science program (PI Bunyo Hatsukade, NAOJ), as well as the realization of ALMA, through the research, development and production of sensitive superconducting SIS (superconductor-insulator-superconductor) tunnel junction mixers.

B. Hatsukade, K. Ohta, A. Endo, K. Nakanishi, Y. Tamura, T. Hashimoto, K. Kohno, Nature 510, 247 (2014)



Reliable teleportation between separated quantum computer chips

Realizing robust quantum information transfer between long-lived qubit registers is a key challenge for quantum information science and technology. We demonstrated teleportation of arbitrary quantum states between diamond chips separated by 3 meters. We prepare the teleporter through photon-mediated heralded entanglement between two distant electron spins and subsequently encode the source qubit in a single nuclear spin. By realizing a fully deterministic Bell-state measurement combined with real-time feed-forward we achieve teleportation in each attempt while obtaining an average state fidelity exceeding the classical limit. These results establish diamond spin qubits as a prime candidate for the realization of quantum networks for quantum communication and network-based quantum computing.

W. Pfaff, B. Hensen, H. Bernien, S. B. van Dam, M. S. Blok, T. H. Taminiau, M. J. Tiggelman, R. N., Schouten, M. Markham, D. J. Twitchen, R. Hanson, Science 345, 532–535 (2014)

COLUMN

BACK TO REALITY

And yet another academic year kicks off again. What year is this? 2014, check. Which year did I start? 2011, check. Whoa! Wait a minute - three years have gone by?! How did that happen? Why didn't anybody tell me?! So my last year has started?? Oh boy [picture me becoming pale in the face], in a year's time I'm expected to have written a book, drawn some very profound and groundbreaking conclusions and am expected to head off to the next step in my career?

"Ah", I hear post-docs thinking, "the final year grad student - been there, done that. Feel so sorry for those guys (NOT!)…" Well, I guess last-year's grads are easy to recognize: walking hastily through the corridor, a bit pale faced, sleep deprived, maybe a nervous twitch or two. You've got it, that's us. To be honest, I actually don't feel all of this (yet), but the ***what's next***? question has definitely been popping up in my mind more often these days. Three years ago, doing a Ph.D. to me was a form of safe and comfortable intellectual escapism, curiosity-driven but also having that delightful feeling of being allowed to not think about ***what next***? for the following three years. But here I am again: what's next?

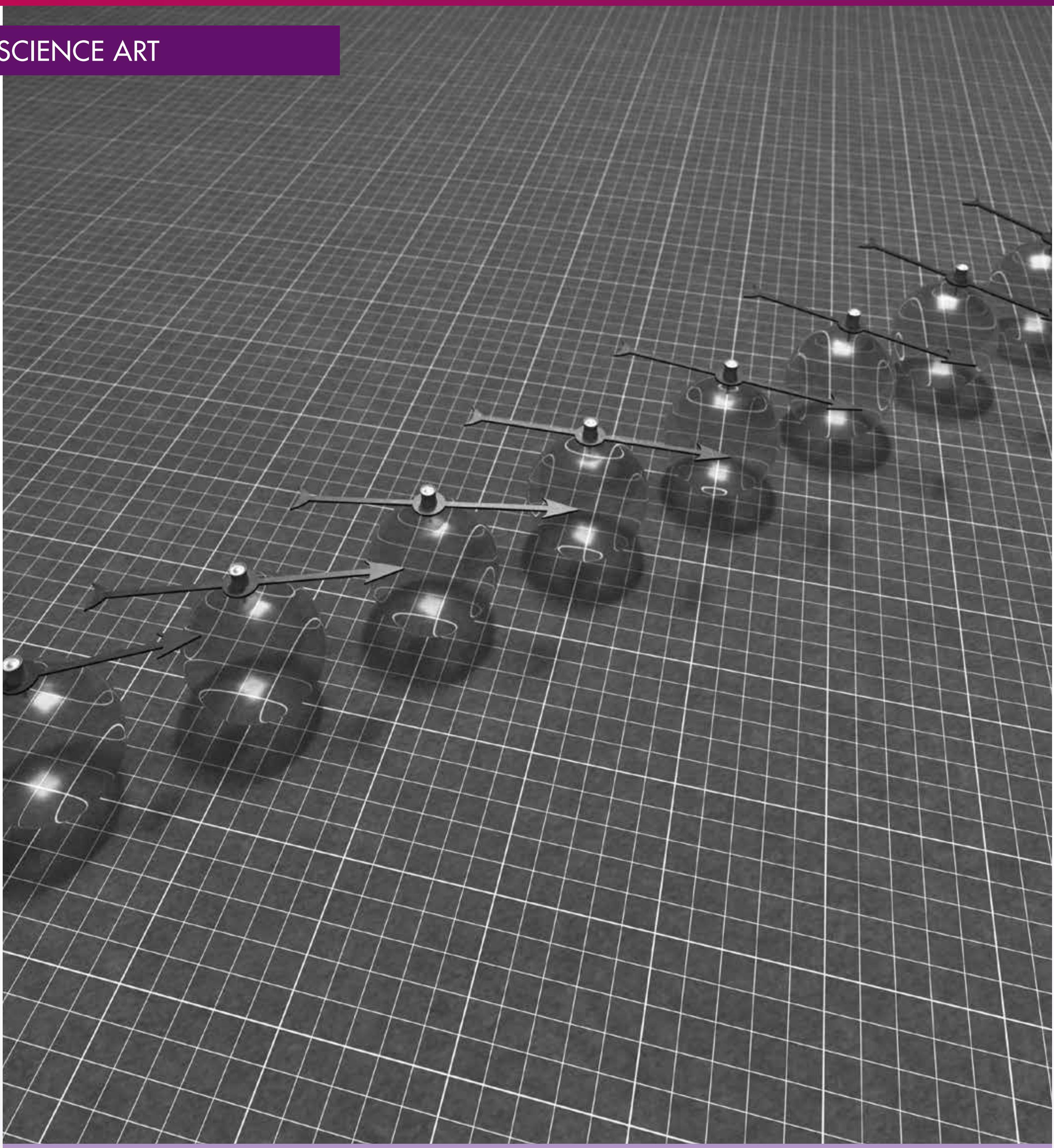
Instead of ***what***, George Whitesides recently reminded a group of us over lunch - you should ask ***why***? Why are you doing what you're doing now? And so in that next step, what is your 'Big Why'? Is it because you're on to the next best thing after sliced bread? Because your research is going to save millions of lives? In both cases: quite unlikely. But what's wrong with ***because I like it***, I hear you thinking. Sure, but what if your research does not serve any greater good than feeding your curiosity? I guess that is not wrong per se. But should society pay for a lifetime of this? Should society pay for you (and me) wanting to escape from society, hoping that somehow, some day something will come out?

Anyhow, an interesting lunch it was, with more food for thought than actual calories. Until the 1950s - George-the-walking-encyclopedia lectured - the vast majority of research was done with a practical purpose - think Bell labs, NatLab, cold war, etc. All fine, but should research always have a direct practical purpose, as many politicians these days advocate? Isn't that a one-way ticket to short-term goals and stagnation, to a modern medieval era?

For George, his answer was clear: the bigger why is making a lasting contribution to society, as most of us witnessed during his talk in the Atomium in Brussels. Then again, the bigger why is a lot easier to fill in when you do not have to worry about job prospects. And a lot easier in hindsight, especially when you've become an established George-type big shot. Again, food for thought. Talking about which: I suggest talking over the ***whats and whys*** over dinner with my direct peers: I call for a last years' grad student dinner club. And my word of advice for younger grad students: enjoy your intellectual retreat while it lasts!

•Bojk Berghuis

SCIENCE ART



Artist impression of an artificially designed atomic chain hosting confined spin wave states. The image was featured on the cover of the August 2014 issue of Nature Materials, in connection to 'Imaging of spin waves in atomically designed nano magnets' by A. Spinelli, B. Bryant, F. Delgado, J. Fernández-Rossier and A. F. Otte | Nature Materials 13, 782 (2014) (Image by Sander Otte)

Please send suggestions for 'Science Art' to Amanda van der Vlist, A.vanderVlist@tudelft.nl

CONTRIBUTE TO THE NEWSLETTER

Input to forthcoming newsletters is very welcome. Please send any relevant material to Amanda van der Vlist (A.vanderVlist@tudelft.nl).
If you like to contribute to this newsletter as an editor, please contact Cees Dekker (C.Dekker@tudelft.nl).

COLOFON

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