KAVLI NEWSLETTER
Kavli Institute of Nanoscience Delft
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Interview with Stefani Valianti, PhD in KIND Quantum-Bio and Martin Depken, Department Chair BN

Stefani's researches on molecular and biomolecular charge- and energy transport, in particular on electron transfer (ET) mechanisms in molecules and molecular junctions. Her current research in Blanter Group (QN) in close collaboration with Jakobi Lab (BN) concentrates on studying bacterial species that have been found to produce conductive structures, specifically Desulfovibrionaceae family wires, also known as cable bacteria.

Dr. Martin Depken is associate professor and chair of BN. He uses statistical mechanics to understand how biological function arises and is maintained in the machines that work the genetic code. The Depken group seeks to understand some of the most important structure-function relations in biology, health, and technology today.

Martin: We got a new KIND fellow at Kavli in 2022. Stefani, good to meet you. You have been in Delft for a year now, so we thought we should get to know you a little better. Let us start with where you started your journey.

Stefani: I am from Cyprus, the Greek part of the island. I did my undergraduate at the University of Cyprus in Nicosia, and stayed on to complete a MSc and PhD under the supervision of Professor Spiros Skourtis.

Martin: Lovely place to call home! How come you found your way to do a postdoc in the Netherlands, and what are you working on here?

Stefani: My project is about cable bacteria. It all started back in 2014, with the discovery that bacteria can form networks of very thin structures called nano-wires. These wires are used to export excess electrons from the bacterium's metabolism to the environment, and have surprisingly high conductivity considering their size and composition of proteins. This is where biology and quantum mechanics meet! Back then, Herre van der Zant (QN) and Bertus Beaumont (BN) started a project to characterize the conductive properties of these structures. My PhD supervisor heard about the KIND fellowship, and I reached out to Yaroslav Blanter (QN). Given my expertise in molecular and bio-molecular electron transport phenomena in protein

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FROM THE DIRECTORS

Spring time is upon us - the birds and the trees have woken up from hibernation and the days are becoming longer. In keeping with the season, the KIND Newsletter is also waking up from hibernation. In the year since the last Newsletter, many exciting things have happened at our KIND institute, and as a result this Newsletter is packed! We welcomed new faculty members, many new PhD students, postdocs and technicians, and a new Kavli co-director (yours truly took over the baton from Chirlmin Joo). You can read about the plans of two of our new KIND researchers, Stephanie Valianti and Marianne Bauer, on pages 2 and 3. We are very proud of the many important prizes and recognitions bestowed on KIND researchers: the Physica prize for Nynke Dekker, Ammodo Science Award for Stan Brouns, VICI awards for Stephanie Wehner and Simon Gröblacher, and Minerva Prize for Anne-Marije Zwerver. Meanwhile lots of exciting science happened, as evidenced by a wave of PhD theses and papers. All this research requires a lot of patience, so you'll be pleased to read first-hand advise on how to cope with this in the column by Evert Stolte on page 4. Meanwhile we have prepared an exciting calendar of events for 2023. For now, please save the date for FYSICA 2023 organized by the Netherlands' Physical Society with a double Kavli touch (26 May), the Kavli Colloquium by prof. Miriam Goodman from Stanford University (20 June), and the Kavli Day (5 October).

Gijsje Koenderink

SELF-INTERVIEW - MARIANNE BAUER

Background:
I studied chemistry and maths at the University of St Andrews, and did a master's on protein folding in the Chemistry department at Cambridge. I transitioned into theoretical physics with a master's on biexcitons, and did my PhD on cold atomic gases, also at Cambridge. I realized I missed biological applications in my PhD, got excited by biophysics and never looked back: during my PostDoc in Munich, I worked on the importance of spatial structure in ecological model systems, and during my PostDoc in Princeton, I learnt about ideas of optimality (expressed in an information theoretical framework) in biological contexts, especially to gene expression in the fly embryo. I joined the BN department in March 2022.

Research Plans:
I'm starting my theoretical group at BN. I want to understand whether it is useful to see the architecture of the genome and its regulatory networks as optimized for "efficiency" of gene expression. I'm excited to learn about new biological systems in the department, such as yeast, viruses, stem cells or just synthetic contexts. In addition, I would like to learn more about stochasticity in processes around sensing of chemical or mechanical signals in general. If anyone has similar interests, I would be happy to chat.

First impression of the Kavli Institute:
I enjoyed my first Kavli day last summer a lot - it was great to meet many colleagues, also from QN, which for me was the first time! I also enjoyed meeting Amy and Jeff from the foundation. In general, I enjoyed the collaborative atmosphere at the Kavli Institute, which I got to experience when we thought about joint research proposals. I would be excited for more Kavli-related science meetings, or interactions. I'm already looking forward to the next Kavli Day!

Unusual hobbies/facts about me:
I'm quite interested in film and theater, as well as philosophy and history of science. I also like exploring new places such as the White Sands National Park in New Mexico (a large flat area of gypsum crystals in between mountain ranges that formed in the last ice age). I do unfortunately get quite cold (even in our department!), so I enjoyed being able to walk around the sands without a coat in January, while it had snowed just three hours away. I really like and am looking forward to exploring more of the Dutch museums.

Marianne exploring the White Sands National Park, New Mexico.

Science anecdote:
I like thinking about information-theoretic quantities, and really enjoy the often quoted story of how John von Neuman recommended Shannon to call his information-theoretic uncertainty function entropy: "You should call it entropy for two reasons: First your uncertainty function has been already used in statistical mechanics under that name, but second and more important, no one really knows what entropy really is - so in a debate you will always have the advantage." It always makes me laugh because it is true that in (sloppy) debates using powerful sounding vocabulary can make one look smart, but of course when one actually wants to communicate or learn something about nature doing so is useless (unless everyone else in the group has a precise picture of what one is talking about); and I enjoy that John von Neumann elegantly and funnily points out that scientific debates are sometimes a bit vague. I really hope that by being more clear/specific we can learn about how precise biological systems are under specific conditions.

1st Dutch cryo-EM school supported by KIND

Summer 2022 saw the first occurrence of the Dutch Cryo-EM school taking place at BN in Delft and at the National Center for Electron Nanoscopy in Leiden. The school was generously sponsored by the Netherlands Infrastructure for Electron Microscopy (NEMI) and by KIND. From 27 June to 02 July 2022, twenty PhD students and postdocs from Dutch universities and research institutes had the chance to apprehend the state-of-the-art in the practice of cryogenic electron microscopy (cryo-EM) applied to biomolecular complexes in lectures and practicals given by international leaders in the field. The participants learned about practical aspects in optimally aligning transmission electron microscopes for phase contrast imaging, the ins and outs of advanced image processing for single particle analysis and electron tomography, and how to interpret the resulting data to extract detailed information on the nanoscale physics and chemistry of biomolecular machines. Moreover, the week-long interaction allowed the participants to expand their own scientific networks, both through interactions with the experts who stayed on

for the full duration of the school, and with their peers at different research organisations throughout the Netherlands. The school, co-organised by BN and colleagues in Utrecht and Leiden, was a great success and highly appreciated by the very positive feedback from both participating students and invited teachers. We hope to make this school a new (biannual) tradition and thank KIND for their generous support in making this happen!

More about our research in Cryo-EM: http://cryoem.tudelft.nl/

› **Continued from page 1**

structures and my skills in analytical calculations, code development and ab-initio quantum chemistry computations (gained through my MSc and PHd studies), the project was perfect for me, and I soon wrote the proposal for the KIND fellowship supported by Yaroslav and Arjen Jakobi in BN.

In short, we want to build a framework to describe the behaviour of these structures. We want to understand how the conductivity depends on temperature, voltage, length, and so on. To help us we have recent experimental results from Herre's group, further experiments are underway, and we plan to look at the structure of these wires together with Arjen's group.

Martin: Nice to see that this line of research continues within Kavli, and between our departments! You are yourself a physicist, but now looking at structures produced by a living system. Is this connection to biology something you consciously sought out yourself?

Stefani: I had worked on the electronic properties of protein structures before, but taking my work in the direction of this specific project was an opportunity, more than a long term plan. The chance to use my skills and experience to form a connection to the biology of bacteria arose, it sounded exciting, and I took it.

Martin: Nice! Life has a tendency to take unexpected turns, and one has to be ready to grab the opportunities as they come along! What has been the effect of getting the KIND fellowship?

Stefani: I am at TU Delft! The level of the science that is performed here is so high, and this gives me a lot of opportunities to develop as a scientist and build my CV. Here you can find experts in many fields, so you have the chance to discuss your work with colleagues at a very high level. This is very important for me. Also, here I have access to state of the art infrastructure. For me this mainly means computing power, which is very important for the success of my project!

Martin: Good to hear you are making the most out of being here! How was it arriving as an international postdoc here in Delft?

Stefani: Everyone has been so helpful! I have felt really welcomed, with everyone willing to take the time to discuss. Everyone speaks good English, and there are never any communication problems at work or in every-day life. The department organizes meetings and parties, which made it easy to socialize. This was all very important to me when arriving from abroad and not knowing anyone at first. And, there is also a very large and close-knit Greek community!

Martin: Sounds like you landed well. Any problems you faced as an international arriving in Delft?

Stefani: Finding accommodation was really difficult! There just is not much available. This is of course true for everyone, but arranging accommodation abroad comes with added challenges.

Martin: Now that you settled in in Delft, what do you do in your spare time?

Stefani: I love to organize trips with my friends! I had never been to the Netherlands before getting the fellowship, so we are really taking the chance to explore the country and further into the mainland of Europe.

Martin: With another year left, I am sure you have started to think about your next step. Any idea where you will go next, and what you will do?

Stefani: I want to stay in academia, but where I go will depend on the opportunities that arise.

Martin: Another instance of grabbing what comes along. I have the happy feeling KIND has been a positive force in your life, and I wish you the best of luck with your work here and beyond!

A double Kavli touch at FYSICA 2023

On Friday May 26th, the annual event FYSICA of the Dutch Physics Society NNV will be hosted in Delft. Attended by some 500 participants, FYSICA brings together people from all kinds of backgrounds – academic researchers, high school teachers, policy makers – who share one thing: their passion for physics. During the plenary program, special attention will be given to last year's Physics Nobel Prize, awarded for experiments on entangled photons. There will also be parallel focus sessions on education, diversity, imaging techniques, biophysics and quantum physics.

FYSICA 2023 will be a special day for the Kavli Institute for two reasons. First, Nynke Dekker, professor of single molecule nanoscale biophysics at our institute, will receive the prestigious Physica Prize and give the Physica Lecture. Second, at the end of the day former Kavli Artists in Residence Andrija Pavlovic and Sonja Loncar will give a duo piano concert themed 'Beyond Quantum'. Head over to fysica.nl for registration and more information!

Stan Brouns wins Ammodo Science Award

NEWS - 07 MARCH 2023

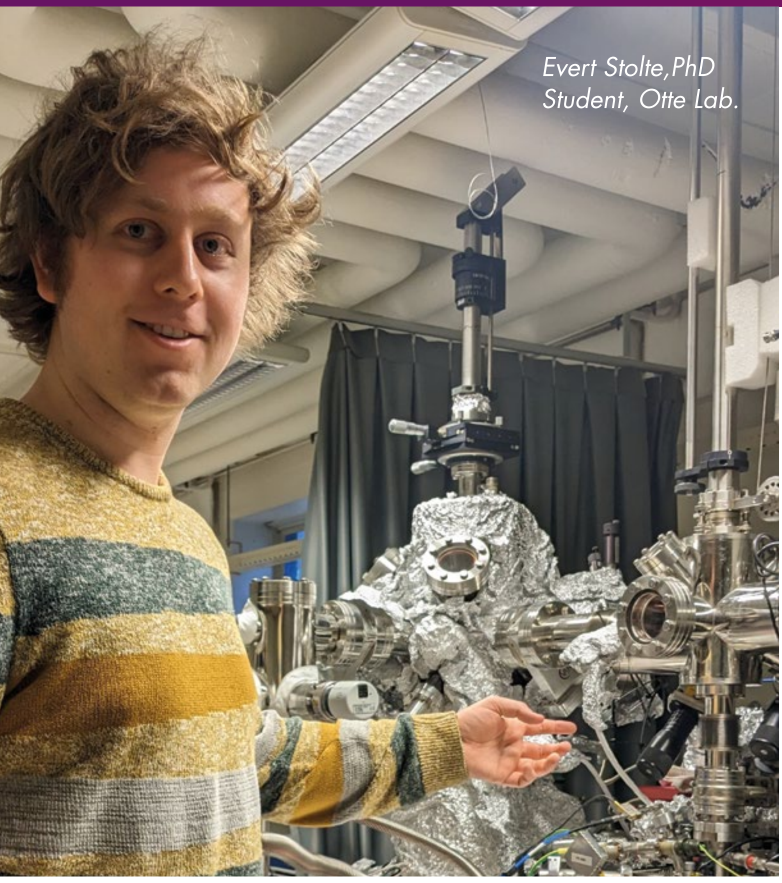
Professor of Molecular Microbiology Stan Brouns is one of the eight laureates of the Ammodo Science Award for fundamental research 2023. Brouns will receive a cash prize of 350,000 euros. In the coming years, he can use this prize to explore new avenues of fundamental research on the battle between bacteria and viruses.

Arjen Jakobi - TU Delft scientists reveal molecular structure of bacterial gas vesicles

NEWS - 03 MARCH 2023

Similar in function to ballast tanks in submarines or fish bladders, many water-based bacteria use gas vesicles to regulate their floatability.

In a publication in Cell, scientists from the Departments of Bionanoscience and Imaging Physics now describe the molecular structure of these vesicles for the first time. These gas vesicles were also recently repurposed as contrast agents for ultrasound imaging.



Evert Stolte, PhD Student, Otte Lab.

We at the Kavli Institute of Nanoscience Delft are a varied bunch of research groups, not only covering a broad range of research topics, but also doing all kinds of different day-to-day things. There is a lot of sample prep involved in nanoscience, from sputtering to cell growth. Elsewhere a lab measures exclusively with one big instrument, while another lab has an assortment of devices that are used throughout the day. Be it in the cleanroom or in a lab setup, there is one thing we all, unfortunately, spend a surprising amount of our working hours doing: waiting. And it's not just the experimentalist. Theorists have to wait for code to finish running all the time, too. You could say it's one of those things that brings us all together. Personally, I'm in the category of mostly measuring with one complex machine. As a PhD candidate in the Otte Lab, I operate a Scanning Tunneling Microscope, which is a notoriously slow type of microscope, so I'm no stranger to waiting.

A proper atom-resolved image of 70x70 nm might take half an hour and I'm doing a lot of them. There is a good chance you are reading this article while waiting at this very moment on something more important than the Kavli newsletter, which only further proves the relevance of this topic I want to cover here: 'waiting during research'.

Not every wait is the same. With these one-hour-long measurements I'll just press start and do something else. God knows there are enough emails to answer ("Would you like to write an article for the Kavli newsletter?") and the tasks of a researcher are never limited to just the work in the lab (like writing an article for the Kavli newsletter). Typically I'm able to make good use of this time. The other types of work wouldn't get done if I didn't have to wait for my results to arrive.

Although, at some point a process might take so long that you would have to plan your day around it entirely. If one step of many takes 12 hours, it feels like a waste not to try finishing two steps each day instead of only one overnight. Waiting is in conflict with normal working hours. Then there is multi-day or even weeks of waiting. I've had to postpone all and any progress on a main project because I was waiting for one delivery that took 2 weeks longer than expected. That felt pretty bad.

However, the most annoying types of waiting, which I am experiencing everyday myself, are actually the very short amounts of waiting. My day-to-day process in the lab is filled with micro decisions followed by short measurements of 20 seconds, followed up with yet a new micro decision. I'm tweaking to optimise or I sweep parameters non-monotonically, always basing my next step on the previous. It requires a certain focus to make the right decisions and progress. Scientific research is generally non-trivial after all.
The bane of my everyday existence are these waiting times in between the micro decisions. They break my focus, even if the interruption is minor. My mind begins to wander and I'm distracted. The experience feels similar as when you get a direct message and your phone is accidentally not on silent ("how is your article coming along?").
According to behavioural science research, this is not surprising. There is a huge library of research that shows humans are impatient and easily distracted. A recent study [1] shows that we get so annoyed by short waiting between sequential choices that we, in the moment, rather choose a significantly lower monetary reward to move all the few-second-long waitings to one big wait at the end.
Trying to make something useful of the times lost also never seems to work. A 2006 study [2] in the context of human-computer interface interactions found that interrupting a main task with small ones may increase the total time to complete them together for up to 27%, compared to moving the small tasks to the end. Furthermore: "... when peripheral tasks interrupt the execution of primary tasks, users (...) experience from 31% to 106% more annoyance." That quote resonates with me.
On the other hand, as things go in (behavioural) science, research also suggests that occasional switching from primary to brief side-tasks can also improve the quality of performance on all tasks. [3] This seems to apply to interruptions in the range of every 20 minutes.

Some of my direct colleagues use music to get through these agonising short decision-wait cycles, and I'm sure many others do too, but songs don't do it for me in this case. Instead, I've recently found my solution in listening to podcasts. I like to play episodes of RadioLab and Freakonomics because it feels like they teach me something unimportant, plus they have huge backlogs. With podcast conversations running around in my head, the waiting gaps get filled and the distraction is no more. My advice next time you get distracted in the lab: reflect whether there is too much going on around you, or rather too little. Is there something you can do, or are you simply waiting? Maybe the wait will have passed by then.

[1] Xu P., González-Vallejo C., Vincent, B.T., *Waiting in intertemporal choice tasks affects discounting and subjective time perception*, J. Exp. Psychol. Gen. 149(12), 2020
[2] Bailey B.P., Konstan J.A. *On the need for attention-aware systems: Measuring effects of interruption on task performance, error rate, and affective state*, Comput. Hum. Behav. 22(4), 2006
[3] Arigo A., Lleras A., *Brief and rare mental ''breaks'' keep you focused: Deactivation and reactivation of task goals preempt vigilance decrements*, Cognition, 118(3), 2011

Vici grants for leading TU Delft researchers

The Dutch Research Council (NWO) has awarded KIND researcher Simon Gröblacher (QuTech) as well as two TU Delft researchers, Valeria Garbin (AS) and Atsushi Urakawa (AS) a Vici grant of up to 1.5 million euros. This will enable the laureates to develop an innovative line of research and further expand their own research group for a period of five years.

Simon *QuTech: "I am very humbled and excited to receive the prestigious NWO Vici grant. It will allow my group to set up a new research direction where we will use a two-level quantum system to create complex quantum states of mechanical oscillators."*

https://www.tudelft.nl/en/2023/tnw/vici-for-valeria-garbin-simon-groeblacher-and-atsushi-urakawa

NEW EMPLOYEES

Giuseppe di Carlo	01-08-2022	PhD	Di Carlo Lab
Rebecca Gharibaan	01-12-2022	PhD	Goswami Lab
Francesco Zatellil	01-12-2022	PhD	Kouwenhoven Lab
Yining Zhang	01-09-2022	PhD	Goswami Lab
Martijn Zwanenburg	01-07-2022	PhD	Andersen Lab
Juan Torres Luna	01-09-2022	PhD	Wimmer Group
Daniel Jirovec	15-09-2022	Postdoc	Vandersypen Lab
Dennis Brinkman	01-08-2022	Software engineer	Vandersypen Lab
Sasha Ivlev	15-10-2022	PhD	Vandersypen Lab
Davide Costa	15-09-2022	PhD	Vandersypen Lab
Cécile Yu	15-09-2022	Postdoc	Veldhorst Lab
Irene Fernandez Fuentez	15-02-2023	Postdoc	Vandersypen Lab
Maurice Maas	01-08-2022	PhD	Ishihara Lab
Shuichang Yu	15-09-2022	PhD	Ishihara Lab
Tim Vroomans	01-10-2022	PhD	Di Carlo Lab
Christina Ioannou	01-08-2022	PhD	Taminiau Lab
Margriet van Riggelen	01-10-2022	PhD	Taminiau Lab
Aleksandr Mokeev	01-10-2022	Postdoc	Dobrovitski Group
Antariksha Das	10-09-2022	Postdoc	Taminiau Lab
Christian Primavera	01-03-2023	PhD	Hanson Lab
Stefani Valianti	01-05-2022	Postdoc	Blanter Group
Roland Mulder	01-05-2022	PhD	van der Sar Lab
Yong Yu	01-06-2022	Postdoc	Groeblacher Lab
Marinus Fischer	01-06-2022	PhD	Kavli Nanolab Delft
Artem Bondarenko	01-07-2022	Postdoc	Blanter Group
Emanuele Urbinati	01-07-2022	PhD	Groeblacher Lab
Pim Vree	01-08-2022	PhD	van der Sar Lab
Maria Adamo	01-09-2022	Project Officer	Quantum Nanoscience
Daniël Adamo Muis	01-09-2022	PhD	Kuipers Lab
Tanko Tanev	01-09-2022	PhD	Greplová Lab
Johanna Zijderveld	01-09-2022	PhD	Akhmerov Group
Clinton Potts	01-09-2022	Postdoc	Steele Lab
Lorenzo Scarpelli	01-10-2022	Postdoc	Groeblacher Lab
Arjan Mejas	01-10-2022	PhD	van der Zant Lab
Samuel Mañas Valero	01-10-2022	Postdoc	van der Zant Lab
Dorian Oser	14-10-2022	Postdoc	Groeblacher Lab
Jana Bauer	01-11-2022	PhD	Groeblacher Lab
Sercan Deve	01-11-2022	PhD	Steele Lab
Chris Soukaras	01-12-2022	PhD	Conesa-Boj Lab
Fabian Gerritsma	01-01-2023	PhD	van der Sar lab
Lidewij Hickey	15-01-2023	Department Manager	Afdelingsbureau
Aram Shojaei	15-01-2023	Intern	Greplová Lab
Valentina Gualtieri	15-01-2023	PhD	Greplová Lab
Naomi Spek	15-08-2022	MA	Afdelingsbureau
SaFyre Reese	01-09-2022	PhD	Gijsje Koenderink Lab
Friedrich Kleiner	01-09-2022	Postdoc	Marie-Eve Aubin-Tam Lab
Van Herck	01-09-2022	PhD	Cees Dekker Lab
Brian Analikwu	01-09-2022	PhD	Cees Dekker Lab
Amber Van Landschoot	15-09-2022	Guest Postdoc	Cees Dekker Lab
Jack Tait	15-09-2022	PhD	Sander Tans Lab
Son Marapin	01-10-2022	Guest Postdoc	Gijsje Koenderink Lab
Ingo Nettersheim	01-10-2022	Postdoc	Marie-Eve Aubin-Tam Lab
Orozco Monroy	01-10-2022	PhD	Marileen Dogterom Lab
Miyase Tekpinar	01-10-2022	PhD	Kristin Grussmayer Lab
Jorge Barrasa Fano	31-10-2022	Guest Postdoc	Gijsje Koenderink Lab
Le-Vaughn Naarden	01-11-2022	Guest Postdoc	Cees Dekker Lab
Archana Sivaraman	15-01-2023	PhD	Chirlmin Joo Lab
Olga Rook	01-02-2023	PhD	Marileen Dogterom Lab
Aleksandra Makowiecka	01-02-2023	Guest Postdoc	Gijsje Koenderink Lab
Ivy Liang	01-02-2023	PhD	Gijsje Koenderink Lab
Amina Avan	01-02-2023	Guest Postdoc	Chirlmin Joo Lab
Sinan Kilavuzoglu	01-02-2023	Guest Postdoc	Chirlmin Joo Lab

Lieven Vandersypen joins lunch with King & Queen

Lieven Vandersypen joined a lunch with King Willem-Alexander and Queen Máxima at Noordeinde Palace. The monarchs want to express their appreciation to so-called 'uitblinkers' (high achievers): people who have distinguished themselves by a special achievement in various national sectors, such as culture, science or sports. A total of 27 guests were invited.

QuTech's Director Research Lieven Vandersypen was invited after he received the Spinoza Prize, the highest award in Dutch science.

https://qutech.nl/2022/12/14/lieven-vandersypen-joins-lunch-with-king-queen/

Minerva Prize awarded to Anne-Marije Zwerver

The jury of the Minerva Prize 2022 has selected Anne-Marije Zwerver (QuTech, TU Delft) as the winner from a series of impressive nominations. This prize is intended for young, promising female or non-binary physicists in the Netherlands, who excel in a field of physics, experimentally and/or theoretically.

The jury was very impressed by Anne-Marije's work, both in the field of physics and in the field of outreach, education and science communication. Anne-Marije Zwerver obtained her PhD in 2022 and has already made considerable progress as a PhD candidate. She led the measurements of the first quantum dot qubits made in an industrial cleanroom, an achievement that made headlines worldwide. She was also the first to send an electron spin back and forth across multiple silicon quantum dots. During her PhD she lectured several times at major conferences by personal invitation; the fact that a PhD student receives this kind of personal invitation is quite unusual.

https://qutech.nl/2023/01/18/minerva-prize-awarded-to-anne-marije-zwerver/

Cum Laude to dr. Lucia Baladauf for "Rebuilding Cytokinesis One Molecule at a Time"

Cells are the fundamental units of life. They make up all living things, from bacteria that live in the soil, to archea that give thermal springs their bright colors, to trees and humans. All of these cells share some common functions: they build themselves from basic building blocks, following the instructions of their genetic blueprint, and procreate by growing and dividing. The building blocks must be taken up from the environment and metabolized, and cell division requires the cell to be able to control its own shape. While these basic tasks are shared across the tree of life, different types of organisms have evolved distinct molecular machineries to complete them. In this thesis, we take a close look at animal cells, and ask how they control their shape as they must do in order to move, eat, sense, and divide.

https://research.tudelft.nl/en/publications/rebuilding-cytokinesis-one-molecule-at-a-time

Dr. Lucia Baldauf obtained her PhD with the distinction Cum Laude on 22 december 2022. Her PhD thesis entitled 'Rebuilding Cytokinesis One Molecule at a Time' was part of the ongoing BaSyC Gravitation project.

Gijsje Koenderink appointed Medical Delta Professor - "Collaboration is the common thread in my work"

"Mechanical forces in cells play an important role in the body, but there is still much unknown about how exactly this works. Experimental biophysicist Prof. Dr. Gijsje Koenderink is researching this at TU Delft. With that knowledge, new technologies for detection of diseases such as cancer can be developed."

Medical Delta is an interdisciplinary collaboration in Zuid-Holland that works on technological solutions for sustainable healthcare.

https://www.medicaldelta.nl/en/news/portrait-and-video-gijsje-koenderink-collaboration-is-the-common-thread-in-my-work

Stephanie Wehner receives NWO Vici grant for innovative research line

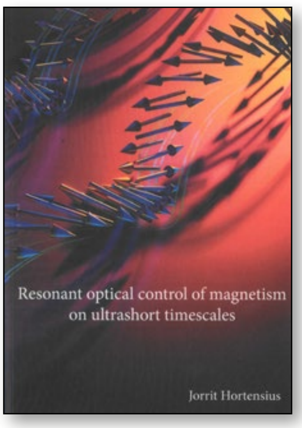
prof. dr. SDC Wehner, Delft University of Technology

The vision of a Quantum Internet is to enable radically new Internet applications by bringing fundamental elements of quantum mechanics – entanglement – to Internet users around the world. This makes eavesdropping on communications impossible, for example. But we currently lack the knowledge to program and control these new networks. The gap between hardware and usable software applications must first be closed. This project will develop the first architecture that can make the Quantum Internet programmable so that anyone can develop useful software applications in the future.

The Dutch Research Council NWO announced that Stephanie Wehner will receive a Vici grant. The grant is aimed at senior researchers who have successfully demonstrated the ability to develop their own innovative line of research. Wehner is one of twelve researchers in the Science Domain who receive this grant.
https://qutech.nl/2023/02/23/stephanie-wehner-receives-nwo-vici-grant-for-innovative-research-line/

RECENT PHD THESES

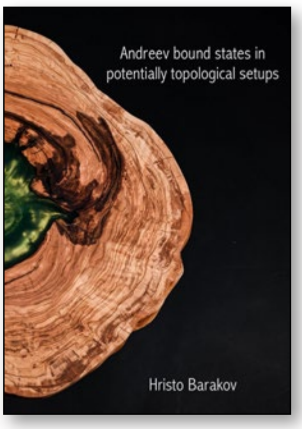
Noémi Bérenger
23 February 2022



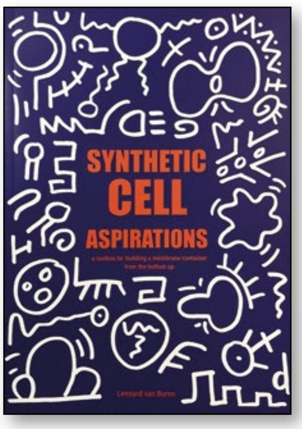
Jorrit Hortensius
8 March 2022

Elisa Godino
6 April 2022

Christine Linne
11 April 2022

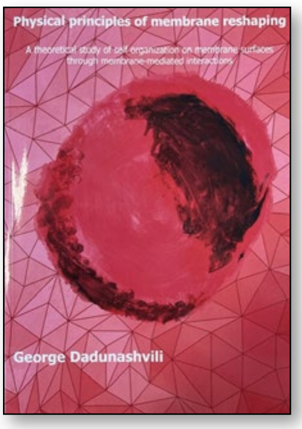


Hristo Barakov
23 May 2022

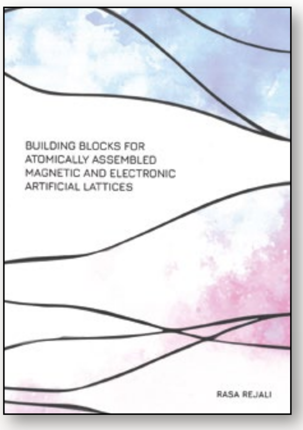


Lennard van Buren
24 May 2022

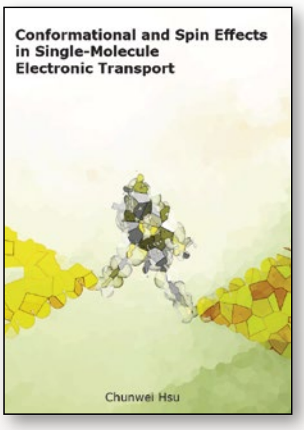
Diederik Laman Trip
8 June 2022



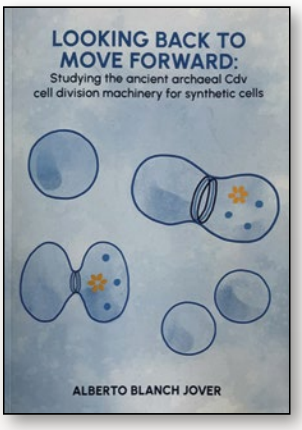
George Dadunashvili
21 September 2022



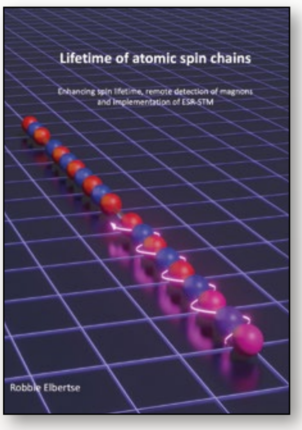
Rasa Rejali
27 September 2022



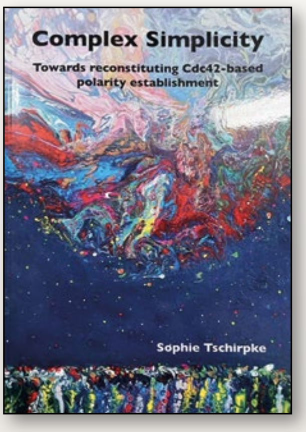
Chunwei Hsu
4 November 2022



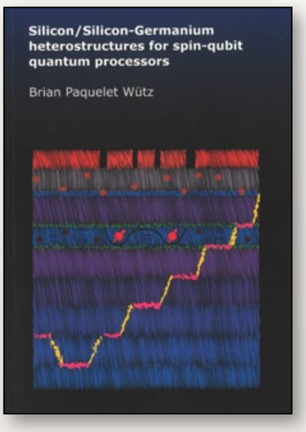
Alberto Blanch Jover
11 November 2022



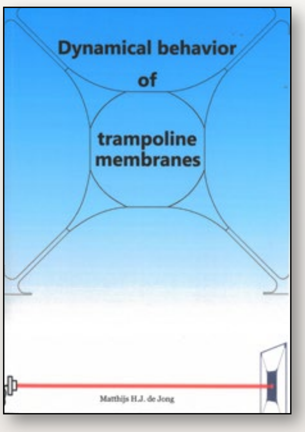
Robbie Elbertse
23 November 2022



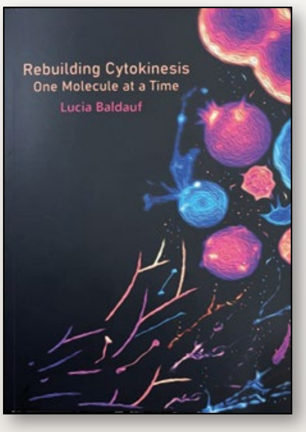
Sophie Tschirpke
2 December 2022



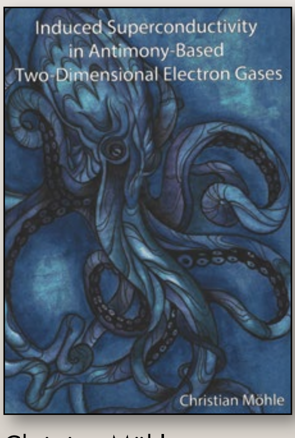
Brian Paquelet Wütz
7 December 2022



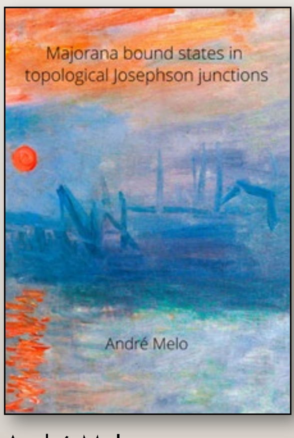
Matthijs de Jong
15 December 2022



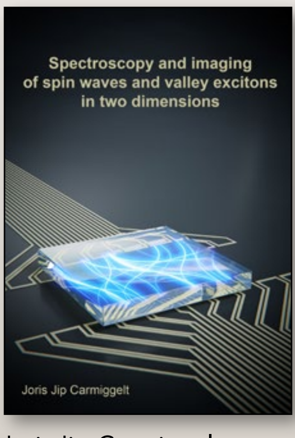
Lucia Baldauf
22 December 2022



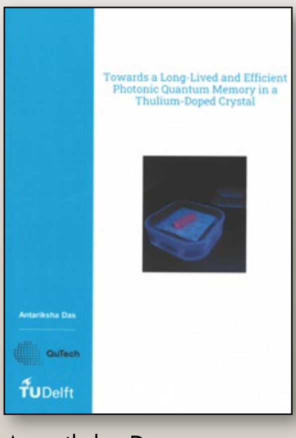
Christian Möhle
09 January 2023



André Melo
12 January 2023



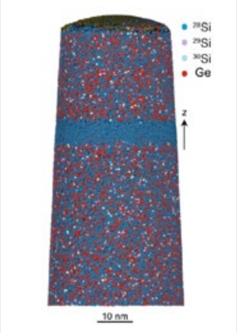
Joris Jip Carmiggelt
26 January 2023



Antariksha Das
01 February 2023

Atomic fluctuations lifting the energy degeneracy in Si/SiGe quantum dots

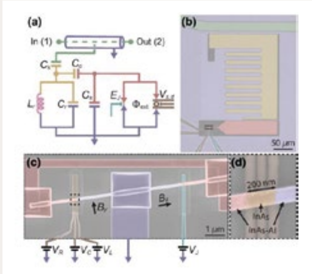
Spin qubits in Si/SiGe quantum dots suffer from variability in the valley splitting which will hinder device scalability. Here, by using 3D atomic characterization, the authors explain this variability by random Si and Ge atomic fluctuations and propose a strategy to statistically enhance the valley splitting



Brian Paquelet Wuetz, Merritt P. Losert, Sebastian Koelling, Lucas E. A. Stehouwer, Anne-Marije J. Zwerver, Stephan G. J. Philips, Mateusz T. Mądzik, Xiao Xue, Guoji Zheng, Mario Lodari, Sergey V. Amitonov, Nodar Samkharadze, Amir Sammak, Lieven M. K. Vandersypen, Rajib Rahman, Susan N. Coppersmith, Oussama Moutanabbir, Mark Friesen & Giordano Scappucci
Nature Communications 13, (2022)

Singlet-doublet transitions of a quantum dot Josephson junction detected in a transmon circuit

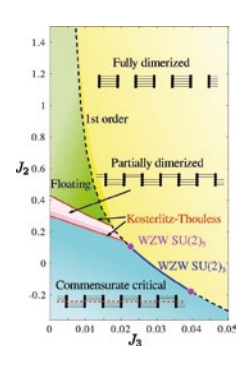
In this work, we confined a single quantum particle, known as a quantum dot, inside a 200 nanometer part of superconducting quantum bit. The properties of this quantum dot can control a phase transition in the surrounding superconductor which we can detect using the same techniques that academics and industries worldwide are using to build large scale quantum computers. Our construction allowed us to observe new interesting physics about this type of phase transition, which previously was only predicted theoretically.



A. Bargerbos, M. Pita-Vidal, J. Ávila, L.J. Splitthoff, L. Grünhaupt, J.J. Wesdorp, C.K. Andersen, Y. Liu, L.P. Kouwenhoven, R. Aguado, A. Kou, B. van Heck
PRX Quantum 3, (2022)

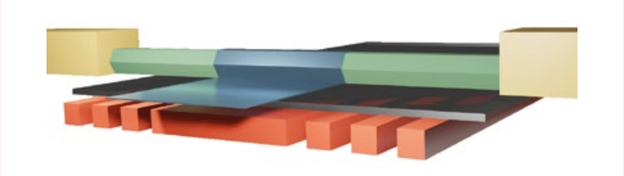
From SU(2)5 to SU(2)3 Wess-Zumino-Witten transitions in a frustrated spin-5/2 chain

We investigate the properties of a frustrated spin-5/2 chain with next-nearest-neighbor two- and three-site interactions, with two questions in mind: the nature of the transition into the dimerized phase induced by the three-site interaction, and the possible presence of a critical floating phase at intermediate values of the next-nearest-neighbor interaction. We provide strong evidence that the continuous transition into the dimerized phase, which has been found to be generically in the Wess-Zumino-Witten SU(2)2Suniversality class up to spin S=2, is SU(2)5 only at two isolated points of the phase diagram, and that it is SU(2)3 in between, in agreement with the presence of two relevant operators allowed by symmetry forSU(2)5, and with the conservation of the parity of the level index along the renormalization flow betweenSU(2)k theories with different values of k. We also find that the dimerization induced by the next-nearest-neighbor interaction is a three step process, with first a small partially dimerized phase followed by a broad critical floating phase with incommensurate correlations before the fully dimerized phase is reached. Implications for the iron oxide Bi3FeMo2O12 are briefly discussed.



Natalia Chepiga, Ian Affleck, and Frédéric Mila
Phys. Rev. B 105, (2022)

Singlet and triplet Cooper pair splitting in hybrid superconducting nanowires

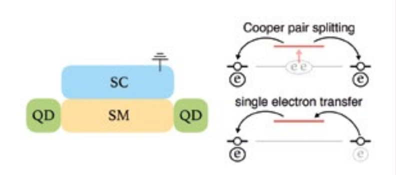


The electrons in a superconductor pair up in twos to form Cooper pairs. Typically, the two electrons in a Cooper pair have opposite spins. In this experiment, we split Cooper pairs into individual electrons and use two quantum dots to study their spins separately. The results verify the normal opposite-spin structure of a Cooper pair, but further show that two electrons with the same spin can also pair up with the help of externally applied magnetic field and spin-orbit coupling.

Wang, G., Dvir, T., Mazur, G.P. et al.
Nature 612 (2022)

Tunable Superconducting Coupling of Quantum Dots via Andreev Bound States in Semiconductor-Superconductor Nanowires

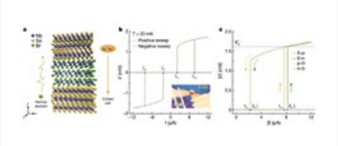
This theoretical study introduces a novel approach for linking two quantum dots through Andreev bound states in a semiconductor-superconductor hybrid. The mechanism enables the prominent occurrence of single electron transfer and Cooper pair splitting, the relative strength of which can be adjusted as needed by altering the chemical potential in the hybrid segment. As a result, the new mechanism holds immense potential for the creation of cutting-edge quantum devices like high-performance Cooper pair splitters and simulated Kitaev chains.



Chun-Xiao Liu, Guanzhong Wang, Tom Dvir, and Michael Wimmer
Phys. Rev. Lett. 129, (2022)

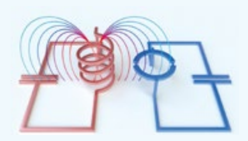
The field-free Josephson diode in a van der Waals heterostructure

Nonreciprocal transport is incredibly important in technology; for example, asymmetry in the current-voltage response in semiconductor junctions has been the cornerstone of computing technology for half a century. However nonreciprocal superconductivity proved elusive, and only in 2020 was the superconducting diode effect (superconducting in one direction while normal conducting in the other) discovered for the first time in a bulk alloy using an applied magnetic field. Here we demonstrated a Josephson diode (JD), created in a quantum material Josephson junction (QMJJ, a junction made up of two superconductors separated by a barrier comprised of a quantum material). A diodic effect was seen without an applied magnetic field; a puzzling result for theoretical physicists but an important advance for potential technological application as nanoscale field control and manipulation remains a challenge. Using an inversion symmetry breaking heterostructure of NbSe2/Nb3Br8/NbSe2, half-wave rectification of a square-wave excitation was achieved with low switching current density, high rectification ratio, and high robustness. This non-reciprocal behaviour strongly violates the known Josephson relations and opens the door to discover new mechanisms and physical phenomena through the integration of quantum materials with Josephson junctions, and provides new avenues for superconducting quantum electronics.



Heng Wu, Yaojia Wang, Yuanfeng Xu, Pranava K. Sivakumar, Chris Pasco, Ulderico Filippozzi, Stuart S. P. Parkin, Yu-Jia Zeng, Tyrel McQueen, Mazhar N. Ali
Nature 64, (2022)

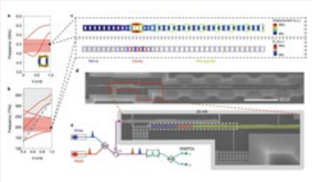
Parametrically enhanced interactions and nonreciprocal bath dynamics in a photon-pressure Kerr amplifier



Making heat flow the wrong way? Using parametric amplification in a nonlinear cavity, we can cool a "hot mode" using a "hotter bath", driving heat the wrong direction, with applications in radio-frequency quantum sensing.

Ines C. Rodrigues, Gary A. Steele, Daniel Bothner
Science Advances 7, (2022)

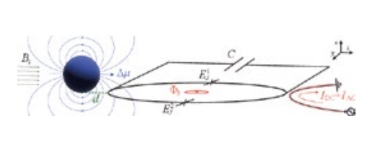
Non-classical mechanical states guided in a phononic waveguide



Over the past years, the group of Simon Groeblacher in the Department of Quantum Nanoscience has demonstrated the possibility to create, store and detect single phonons in photonic/phononic crystal devices, using radiation-pressure optomechanical interactions. Amirparsa Zivari and colleagues have now designed and realized the first waveguide for non-classical traveling mechanical excitations, which was published in Nature Physics. By fabricated the waveguide from thin film silicon they combine the waveguide with a source and detector for non-classical mechanical states, and were able to verify the propagation of these quantum states in the waveguide. These acoustic waves at GHz frequencies are guided in a highly confined nanoscale geometries, with long lifetimes (up to several ms), in particular at low temperatures, enabling the faithful transport of quantum states over centimeter distances on a chip. They further show how non-classical correlations emerging from phonons launched at different times are conserved throughout the propagation in our waveguide, by realizing a phononic First-In-First-Out (FIFO) quantum memory.

A. Zivari, R. Stockill, N. Fiaschi, and S. Gröblacher
Nature Phys. 18, (2022)

Analog Quantum Control of Magnonic Cat States on a Chip by a Superconducting Qubit



We theoretically proposed how to directly and quantum-coherently couple a superconducting transmon qubit to magnons—the quanta of the collective spin excitations, in a nearby magnetic particle. The quantum control scheme leads to tunable, strong non-linear interactions which can be employed to generate magnon-qubit entanglement and magnonic Schrödinger cat states with high fidelity.

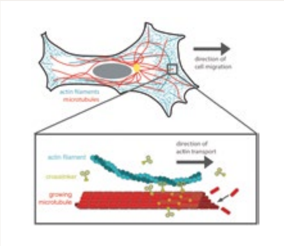
M. Kounalakis, G. E. W. Bauer, and Ya. M. Blanter
Phys. Rev. Lett. 129, (2022)

Mother cells control daughter cell proliferation in intestinal organoids to minimize proliferation fluctuations

Proliferating stem cells are shown to be instructed by their mother on when to specialize. The decision to specialize is critical to understanding organs, as they must produce the right number of cells at the right location. The role of the mother cell in this process has important consequences for controlling these two aspects of intestinal maintenance.

Huelsz-Prince G, Kok RNU, Goos Y, Bruens L, Zheng X, Ellenbroek S, Van Rheenen J, Tans S, van Zon JS:
Elife 11, (2022)

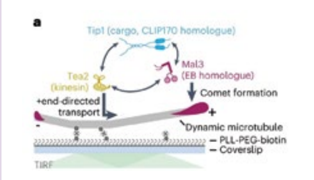
Cross-linkers at growing microtubule ends generate forces that drive actin transport



Complex cellular processes such as cell migration require coordinated remodeling of both the actin and the microtubule cytoskeleton. The two networks for instance exert forces on each other via active motor proteins. Here we show that, surprisingly, coupling via passive cross-linkers can also result in force generation. We specifically study the transport of actin filaments by growing microtubule ends. We show by cell-free reconstitution experiments, computer simulations, and theoretical modeling that this transport is driven by the affinity of the cross-linker for the chemically distinct microtubule tip region. Our work predicts that growing microtubules could potentially rapidly relocate newly nucleated actin filaments to the leading edge of the cell and thus boost migration.

C. Alkemade, H. Wierenga, V.A. Volkov, M. Preciado López, A. Akhmanova, P.R. Ten Wolde, M. Dogterom, G.H. Koenderink,
PNAS 119, (2022)

Multivalent interactions facilitate motor-dependent protein accumulation at growing microtubule plus-ends;

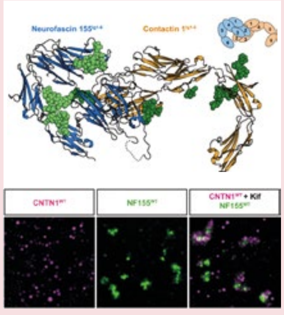


The microtubule cytoskeleton is an intracellular framework that carries out essential roles in cellular processes, such as the establishment of cell polarity. Those processes involve the organization and specific transport of large multi-protein complexes. In this study, we have reconstituted the transport of polarity markers by growing microtubules in fission yeast, and found that these end-binding proteins can be driven into liquid-phase droplets both in solution and at microtubule ends. These results indicate that microtubule ends can act as platforms to organize large multi-protein complexes.

Figure: (see below) Protein assemblies at microtubule ends. 3D renders of cryo-electron tomograms of microtubule ends in blue (plus-end: left; minus-end: right) with bound protein materials (orange).

Renu Maan, Louis Reese, Vladimir A. Volkov, Matthew R. King, Eli O. van der Sluis, Nemo Andrea, Wiel H. Evers, Arjen J. Jakobi, Marileen Dogterom
Nature Cell Biology 25, (2023)

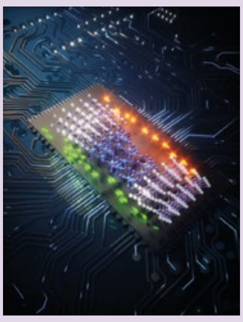
Structural insights into the contactin1 – neurofascin 155 adhesion complex



How do oligodendrocytes wrap a myelin sheet around a neuron? A detailed understanding at the molecular level of the macro-molecular assemblies between oligodendrocytes and neurons is needed to improve our understanding of this process. Together with colleagues in Utrecht, we used X-ray crystallography and complementary biophysical assays to determine the structure of a complex between neurofascin 155 and contactin 1 (ribbon structures). The resulting 3D models revealed that large sugar groups known as glycans (green spheres) are needed to establish this interaction. We confirmed that chemical stripping (+ Kif) of all glycans from contactin 1 (magenta cells), but not from neurofascin 155 (green cells), leads to cell clustering in a model system for cell adhesion.

Lucas Chataigner, Christos Gogou, Maurits den Boer, Cátia Frias, Dominique Thies-Weesie, Joke Granneman, Albert Heck, Dimphna Mejier, Bert Janssen
Nature Communications 13, (2022)

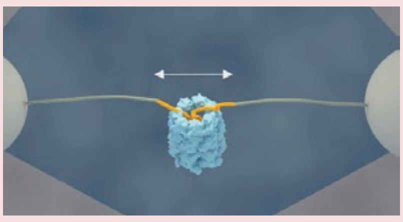
The field-free Josephson diode in a van der Waals heterostructure



Nonreciprocal transport is incredibly important in technology; for example, asymmetry in the current-voltage response in semiconductor junctions has been the cornerstone of computing technology for half a century. However nonreciprocal superconductivity proved elusive, and only in 2020 was the superconducting diode effect (superconducting in one direction while normal conducting in the other) discovered for the first time in a bulk alloy using an applied magnetic field. Here we demonstrated a Josephson diode (JD), created in a quantum material Josephson junction (QMJJ, a junction made up of two superconductors separated by a barrier comprised of a quantum material). A diodic effect was seen without an applied magnetic field; a puzzling result for theoretical physicists but an important advance for potential technological application as nanoscale field control and manipulation remains a challenge. Using an inversion symmetry breaking heterostructure of NbSe2/Nb3Br8/NbSe2, half-wave rectification of a square-wave excitation was achieved with low switching current density, high rectification ratio, and high robustness. This non-reciprocal behaviour strongly violates the known Josephson relations and opens the door to discover new mechanisms and physical phenomena through the integration of quantum materials with Josephson junctions, and provides new avenues for superconducting quantum electronics.

Heng Wu, Yaojia Wang, Yuanfeng Xu, Pranava K. Sivakumar, Chris Pasco, Ulderico Filippozzi, Stuart S. P. Parkin, Yu-Jia Zeng, Tyrel McQueen, Mazhar N. Ali
Nature 604, (2022)

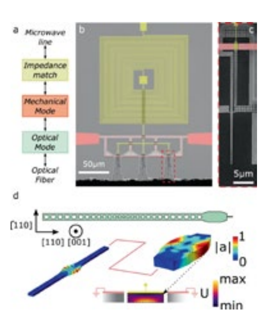
Protein chain collapse modulation and folding stimulation by GroEL-ES



Single-molecule manipulation shows that chaperones can directly stimulate folding and reveal the underlying mechanism. By locally enhancing the hydrophobic collapse within the GroEL cavity, polypeptide chains are collapsed into a smaller size, and hence amino acid interactions are promoted. These findings resolve a longstanding debate on one of the most important proteins in conformational control, and has implications for understanding protein phase separation.

Naqvi MM, Avellaneda MJ, Roth A, Koers EJ, Roland A, Sunderlikova V, Kramer G, Rye HS, Tans SJ:
Science Advances 8, (2022)

Ultra-low-noise Microwave to Optics Conversion in Gallium Phosphide



Mechanical resonators can act as excellent intermediaries to interface single photons in the microwave and optical domains due to their high quality factors. Nevertheless, the optical pump required to overcome the large energy difference between the frequencies can add significant noise to the transduced signal. Here we exploit the remarkable properties of thin-film gallium phosphide to demonstrate bi-directional on-chip conversion between microwave and optical frequencies, realized by piezoelectric actuation of a Gigahertz-frequency optomechanical resonator.

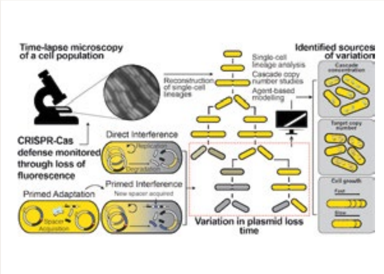
R. Stockill*, M. Forsch*, F. Hijazi, G. Beaudoin, K. Pantzas, I. Sagnes, R. Braive, and S. Gröblacher
Nature Commun. 13, (2022)

On-chip distribution of quantum information using traveling phonons

Physicists from the Gröblacher lab have built a silicon chip with vibrations traveling through it, as if it contained a quantum sound. This marks the first time that scientists are able to store as many qubits as they'd like within a very compact area on this type of chip. Amirparsa Zivari: "Creating a link that allows two quantum devices to talk to each other is very challenging, but that's what we want to achieve. So I am very excited that we are now one step closer to interconnecting different quantum devices and qubits."

A. Zivari, N. Fiaschi, R. Burgwal, E. Verhagen, R. Stockill, and S. Gröblacher
Science Adv. 8, (2022)

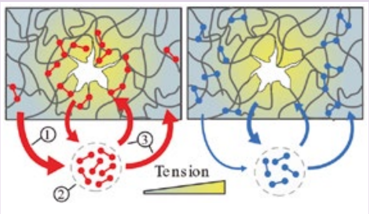
Single cell variability of CRISPR-Cas interference and adaptation



While CRISPR-Cas defence mechanisms have been studied on a population level, their temporal dynamics and variability in individual cells have remained unknown. Using a microfluidic device, time-lapse microscopy and mathematical modelling, we studied invader clearance in Escherichia coli across multiple generations. We observed that CRISPR interference is fast with a narrow distribution of clearance times. In contrast, for invaders with escaping PAM mutations we found large cell-to-cell variability, which originates from primed CRISPR adaptation.

McKenzie RE, Keizer EM, Vink JNA, van Lopik J, Buke F, Kalkman V, Fleck C, Tans SJ, Brouns SJJ:
Molecular Systems Biology 18, (2022)

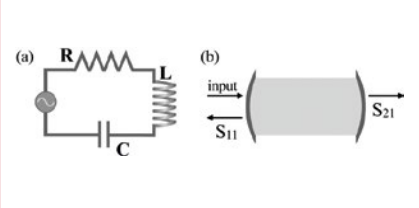
Weak catch bonds make strong networks



Molecular catch bonds are ubiquitous in biology and essential for processes like leucocyte extravasion and cellular mechanosensing. Unlike normal (slip) bonds, catch bonds strengthen under tension. The current paradigm is that this feature provides 'strength on demand3', thus enabling cells to increase rigidity under stress. However, catch bonds are often weaker than slip bonds because they have cryptic binding sites that are usually buried.

Y. Mulla, M.J. Avellaneda, A. Roland, L. Baldauf, W. Jung, T. Kim, S.J. Tans, G. H. Koenderink
Nature materials 21, (2022)

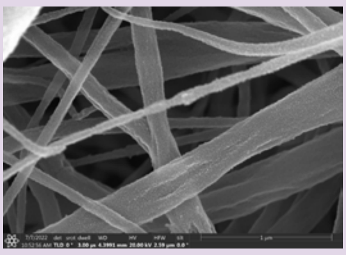
Cavity Magnonics



The article review an emerging field of cavity magnonics - interactions between magnons, the quanta of the collective spin excitations, and electromagnetic fields confined in a microwave or an optical cavity. Recent experimental and theoretical progress was summarized, and perspectives of the field outlined.

B. Zare Rameshti, S. Viola Kusminskiy, J. A. Haigh, K. Usami, D. Lachance-Quirion, Y. Nakamura, C.-M. Hu, H. X. Tang, G. E. W. Bauer, and Ya. M. Blanter
Physics Reports 979, (2022)

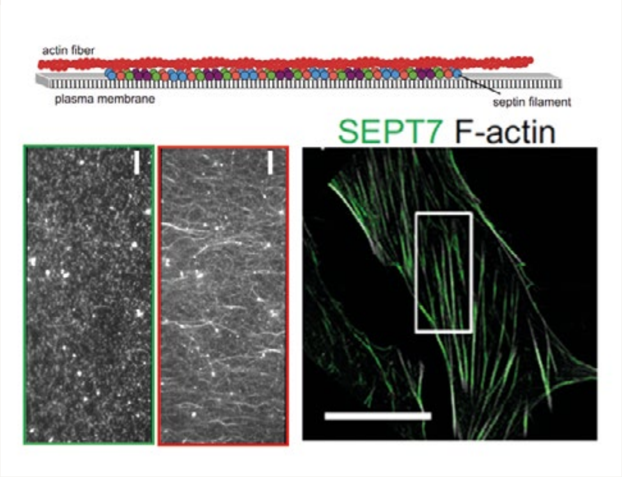
A systematic review and comparison of automated tools for quantification of fibrous networks



Fibrous networks are essential structural components of biological and engineered materials. Accordingly, many approaches have been developed to quantify their structural properties, which define their material properties. However, a comprehensive overview and comparison of methods is lacking. Therefore, we systematically searched for automated tools quantifying network characteristics in confocal, stimulated emission depletion (STED) or scanning electron microscopy (SEM) images and compared these tools by applying them to fibrin, a prototypical fibrous network in thrombi. Structural properties of fibrin such as fiber diameter and alignment are clinically relevant, since they influence the risk of thrombosis. Based on a systematic comparison of the automated tools with each other, manual measurements, and simulated networks, we provide guidance to choose appropriate tools for fibrous network quantification depending on imaging modality and structural parameter. These tools are often able to reliably measure relative changes in network characteristics, but absolute numbers should be interpreted with care.

J de Vries, DM Laan, F Frey, GH Koenderink, PMP de Maat,
Acta Biomaterialia, 157 (2023)

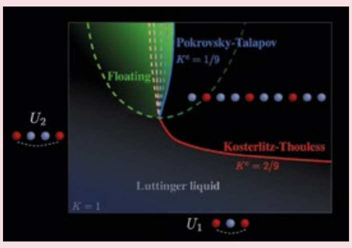
Human septins in cells organize as octamer-based filaments mediating actin-membrane anchoring



Septins are cytoskeletal proteins conserved from algae and protists to mammals. A unique feature of septins is their presence as heteromeric complexes that polymerize into filaments in solution and on lipid membranes. Although animal septins associate extensively with actin-based structures in cells, whether septins organize as filaments in cells and if septin organization impacts septin function is not known. Customizing a tripartite split-GFP complementation assay, we show that all septins decorating actin stress fibers are octamer-containing filaments. Depleting octamers or preventing septins from polymerizing leads to a loss of stress fibers and reduced cell stiffness. Super-resolution microscopy revealed septin fibers with widths compatible with their organization as paired septin filaments. Nanometer-resolved distance measurements and single-protein tracking further showed that septin filaments are membrane bound and largely immobilized. Finally, reconstitution assays showed that septin filaments mediate actin-membrane anchoring. We propose that septin organization as octamer-based filaments is essential for septin function in anchoring and stabilizing actin filaments at the plasma membrane.

C.S. Martins, C. Taveneau, G. Castro-Linares, M. Baibakov, N. Buzhinsky, M. Eroles, V. Milanović, F. Iv, L. Bouillard, A. Llewellyn, M. Gomes, M. Belhabib, M. Kuzmić, P. Verdier-Pinard, S. Lee, A. Badache, S. Kumar, C. Chandre, S. Brasselet, F. Rico, O. Rossier, G.H. Koenderink, J. Wenger, S. Cabantous, M. Mavrakis
Journal of Cell Biology, 222 (2023)

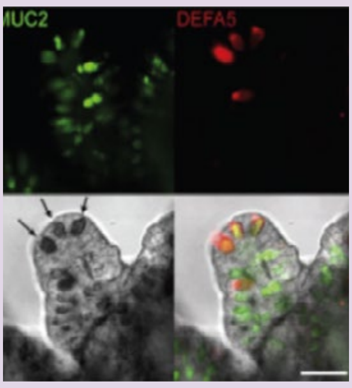
From Kosterlitz-Thouless to Pokrovsky-Talapov transitions in spinless fermions and spin chains with next-nearest-neighbor interactions



We investigate the nature of the quantum phase transition out of density-wave phase in a spinless fermion model with nearest- and next-nearest-neighbor interaction at one-third filling. Using extensive density matrix renormalization group (DMRG) simulations, we show that the transition changes it nature. For weak next-nearest-neighbor coupling the transition is of Kosterlitz-Thouless type, in agreement with bosonisation predictions. For large next-nearest-neighbor repulsion we provide numerical evidences that the transition belongs to the Pokrovsky-Talapov univerality class describing a nonconformal commensurate-incommensurate transition. We argue that the change of the nature of the transition is a result of incommensurability induced by frustration and realized even at zero doping. The implications in the context of the XXZchain with next-nearest-neighbor Ising interaction is briefly discussed.

Natalia Chepiga
Phys. Rev. Research 4, (2022)

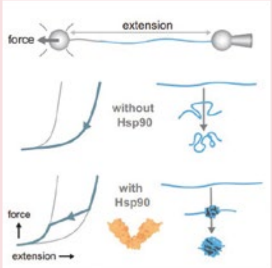
Optimized human intestinal organoid model reveals interleukin-22-dependency of paneth cell formation.



Opposing roles have been proposed for IL-22 in intestinal pathophysiology. We have optimized human small intestinal organoid (hSIO) culturing, constitutively generating all differentiated cell types while maintaining an active stem cell compartment. IL-22 does not promote the expansion of stem cells but rather slows the growth of hSIOs.
In hSIOs, IL-22 is required for formation of Paneth cells, the prime producers of intestinal antimicrobial peptides (AMPs). Introduction of inflammatory bowel disease (IBD)-associated loss-of-function mutations in the IL-22 co-receptor gene IL10RB resulted in abolishment of Paneth cells in hSIOs. Moreover, IL-22 induced expression of host defense genes (such as REG1A, REG1B, and DMBT1) in enterocytes, goblet cells, Paneth cells, Tuft cells, and even stem cells. Thus, IL-22 does not directly control the regenerative capacity of crypt stem cells but rather boosts Paneth cell numbers, as well as the expression of AMPs in all cell types.

He GW, Lin L, DeMartino J, Zheng X, Staliarova N, Dayton T, Begthel H, van de Wetering WJ, Bodewes E, van Zon J et al
Cell Stem Cell 29, (2022)

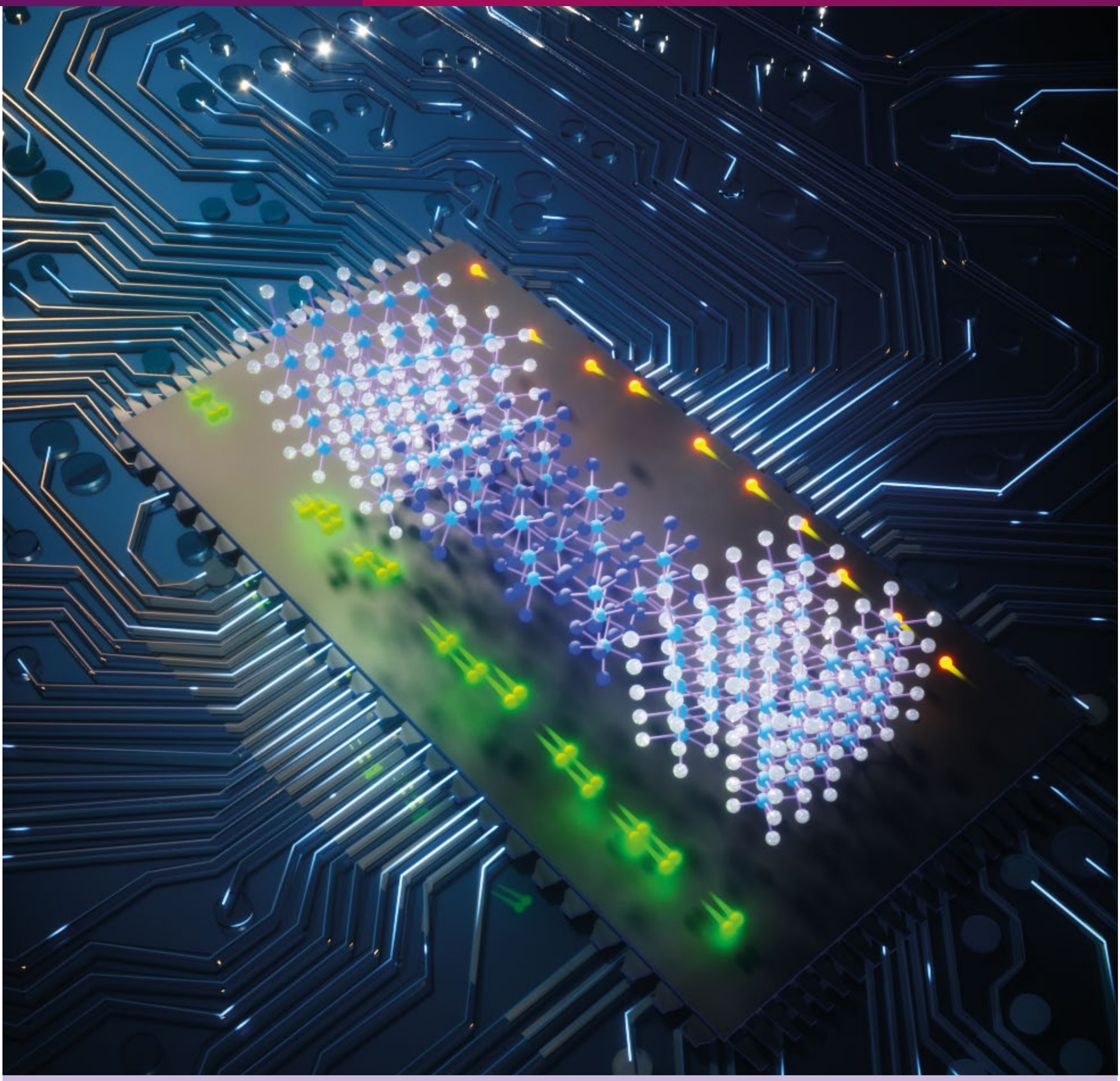
Direct observation of Hsp90-induced compaction in a protein chain



This study shows how the chaperone Hsp90 induces stepwise contractions within unfolded protein chains. This finding has important ramifications for understanding protein folding and interplay between different chaperone classes, as well as associated neurodegenerative diseases.

Mashaghi A, Moayed F, Koers EJ, Zheng Y, Till K, Kramer G, Mayer MP, Tans SJ: Direct observation of Hsp90-induced compaction in a protein chain.
Cell Reports 41, (2022)

SCIENCE ART



An SMC motor protein (blue) can put huge DNA roadblocks (orange) into an extruded DNA loop (white).
For background see B. Pradhan et al, Cell Reports 41, 111491 (2022).
Image credit Cees Dekker Lab / SciXel

KAVLI DAY
5 OCTOBER 2023

Departure: TU Delft Campus

KAVLI COLLOQUIUM
20 JUNE 2023
DECIPHERING WHERE AND HOW TOUCH HAPPENS

Prof. Miriam B. Goodman, *Molecular and Cellular Physiology & Mechanical Engineering, Stanford University*

Time: 15:00 - 17:00
Join us for drinks and mingle after!

TU Delft Campus

Casimir Summer School 2023

The Casimir Summer School is a three-day event for Casimir PhDs and Postdocs. The program will include keynote speakers, several presentation sessions, workshops and poster sessions.
Date: 29-31 August
Location: Grou (Friesland)

Casimir Science Day 2023

Aimed at Casimir PI's, the Casimir Science Day will provide an update on the science going on at Casimir, and introduce new PI's. In addition, by bringing you physically together, we hope to enhance new collaborations between different groups.
Time: 29 June, 12:00 - 18:00
Location: The Hague

COLOFON

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Editorial staff
Gijsje Koenderink, Kobus Kuipers, Chantal Brokerhof, Nina Niemeläinen

Lay out
Haagsblauw

Contact address
Kavli Institute of NanoScience Delft
Delft University of Technology
Department of Bionanoscience

Van der Maasweg 9
2629 HZ Delft
The Netherlands

Phone: +31 (0) 6 41 23 01 71
E-mail: n.niemelainen@tudelft.nl

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