

**DEPARTMENT
of
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PHYSICS**

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RESEARCH HIGHLIGHTS

Publications

Entangling electrons with heat

Entanglement is key for quantum computing and communications technology; Aalto researchers can now extract entangled electrons using heat

A group of scientists from Finland, Russia, China and the USA have shown that temperature difference can be used to entangle pairs of electrons in normal conductors in contact with superconducting structures, providing a new method for producing entangled electrons in a new device. “Quantum entanglement is the cornerstone of the novel quantum technologies. This concept, however, has puzzled many physicists over the years, including Albert Einstein who worried a lot about the *spooky interaction at a distance* that it causes,” says **Prof. Hakonen** (Aalto University), who led the team.

In quantum computing, entanglement is used to fuse individual quantum systems into one to exponentially increase their total computational capacity. “Entanglement can also be used in quantum cryptography, enabling the secure exchange of information over long distances,” explains **Prof. Gordey Lesovik** (visiting researcher from Moscow Institute of Physics and Technology).

The researchers designed a device where a superconductor was layered with graphene and metal electrodes. Doctoral candidate **Ni-kita Kirsanov** (Aalto University) explains how a temperature difference can be used to split entangled pairs of electrons – “Cooper pairs” – allowing each electron to move to a different electrode. “The resulting electrons remain entangled despite being separated for quite long distances.”

The work also has significant fundamental importance. The experiment has shown that Cooper pair splitting can turn a temperature difference into correlated electrical signals in superconducting structures. This scheme may become a platform for original quantum thermodynamical experiments, bringing us one step closer towards applications of the second quantum revolution.

The work was carried out using the OtaNano research infrastructure, which provides state-of-the-art

working environment and equipment for nanoscience and technology, and quantum technologies research in Finland. OtaNano is operated by Aalto University and VTT, and is available for academic and commercial users internationally. Funding: Academy of Finland (**QTF** CoE and ZT’s postdoctoral grant) and Aalto University School of Science (GL’s visiting professorship).

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Matthew Allinson

Citation

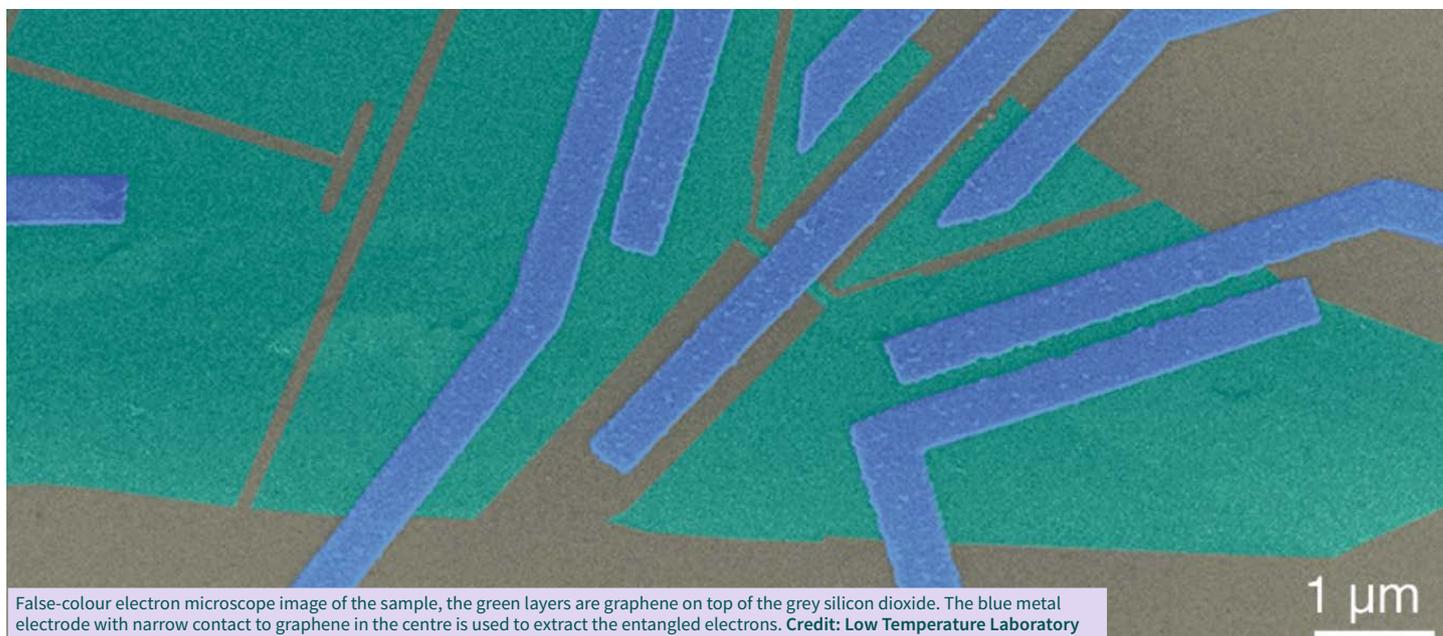
Thermoelectric current in a graphene Cooper pair splitter.

Tan, Z.B., Laitinen, A., Kirsanov, N.S., Galda, A., Vinokur, V.M., Haque, M., Savin, A., Golubev, D.S., Lesovik, G.B. and Hakonen, P.J. 2021. *Nature Communications* 12: 1-7.

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Sustainable optical fibres developed from methylcellulose

Researchers from Tampere University and Aalto University have developed optical fibres from methylcellulose, a commonly used cellulose derivative. The finding opens new avenues to short-distance optical fibres using sustainable and environmentally benign fibre processing. The finding was published in the journal *Small*.

State-of-the-art silica glass optical fibres can carry light signals over tens of kilometres with very low optical loss, providing high-capacity communication networks. State-of-the-art silica glass optical fibres can carry light signals over tens of kilometres with very low optical loss, providing high-capacity communication networks. However, their brittleness, low stretchability and energy intensiveness make them less suitable for local short-range applications and devices such as those in automotives, homes, and medical settings. The sustainable solution to these may be found within biopolymer-based optical fibres.

“The wide availability of cellulosic raw materials provides an excellent opportunity to unravel the hidden potential of renewable materials for practical applications through sustainable fibre processing routes,” says **Assoc. Prof. Nonappa** (Tampere University), whose team is developing biopolymer-based optical fibres for

short-distance applications.

Conventional polymer or plastic optical fibres are processed using relatively high temperatures and hazardous chemical treatment. “By using methylcellulose hydrogel, we have shown that optical fibres can be produced at room temperature using a simple extrusion method without any chemical crosslinkers. The resulting fibres are highly transparent, mechanically robust, flexible and show low optical loss,” Nonappa states.

In addition to pure light signal transmission, the methylcellulose optical fibres can be feasibly modified and functionalized. “The hydrogel matrix allows straightforward addition of various molecules and nanoparticles without compromising the mechanical properties or light propagation abilities of the fibres making them suitable for multifunctional sensors”, says doctoral researcher **Ville Hynninen** (Aalto University). For example, incorporating an extremely low

mass fraction of protein-coated gold nanoclusters produced luminescent optical fibres, and acted also as a fibre-based toxic metal ion sensor. The abundance of cellulosic derivatives and raw materials encourage further research and optimization of cellulose-derived optical components and devices.

The work results from a collaboration between the research groups of Prof. Nonappa and **Prof. Olli Ikkala** and **Zhipei Sun** (Aalto University). Funding: Academy of Finland’s **Photonics Research and Innovation** (PREIN), **FinnCEREs Materials Cluster** flagships and **HYBER Centre of Excellence**.

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Matthew Allinson

Citation

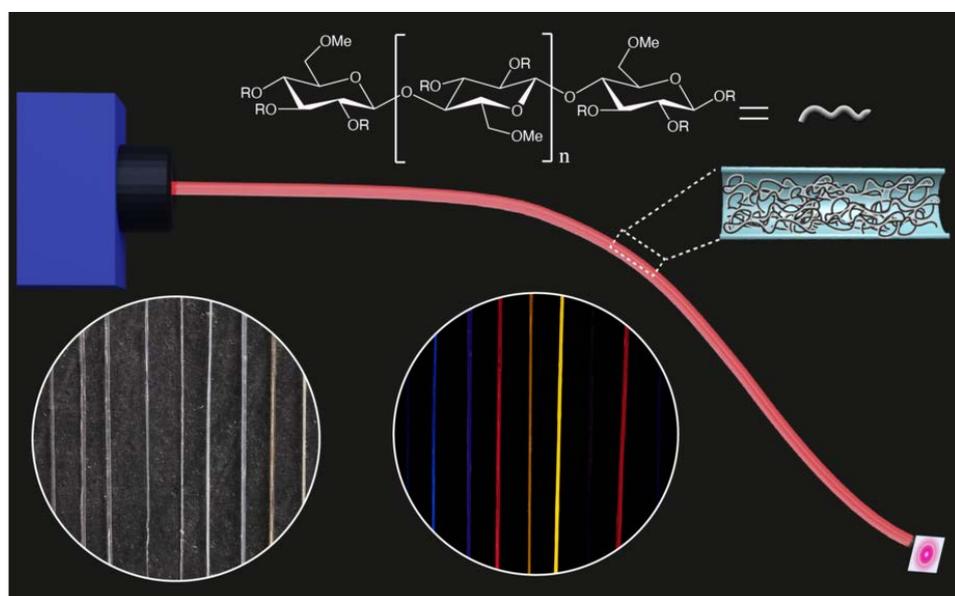
Luminescent gold nanocluster-methylcellulose composite optical fibers with low attenuation coefficient and high photostability.

Hynninen, V., Chandra, S., Das, S., Amini, M., Dai, Y., Lepikko, S., Mohammadi, P., Hietala, S., Ras, R.H., Sun, Z. and Ikkala, O. 2021. *Small*, p.2005205.

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Schematic illustration of a light coupled optical fibre and photographs of methylcellulose-based optical fibers under ambient light and UV light. Credit: Ville Hynninen and Nonappa

A path to graphene topological qubits

Researchers demonstrate that magnetism and superconductivity can coexist in graphene, opening a pathway towards graphene-based topological qubits

In the quantum realm, electrons can group together to exhibit interesting behaviors like magnetism and superconductivity. These two behaviors are often antagonists: the existence of one often destroys the other. However, when forced to coexist artificially, an elusive state called a topological superconductor appears. This is exciting for researchers trying to make topological qubits, but until now, designing and controlling topological qubits has remained a challenge.

To overcome the elusiveness of topological superconductors, which are remarkably hard to find in natural materials, physicists have developed methodologies to engineer these states using materials that allow them to finely tune both the magnetism and superconductivity. For this, researchers have turned to graphene. Although the existence of magnetism and superconductivity have been shown independently, their coexistence has remained elusive in graphene.

In a recent breakthrough experiment, researchers from Spain, France, and Portugal used the theoretical support of **Prof. Jose Lado** (Aalto University) to show that single layers of graphene can host

magnetism and superconductivity simultaneously. The researchers induced superconductivity in graphene by depositing an island of a conventional superconductor close to grain boundaries, naturally forming seams in the graphene that have slightly different magnetic properties to the rest of the material. The superconductivity and grain boundary magnetism gave rise to *Yu-Shiba-Rusinov states*, which can only exist in a material when magnetism and superconductivity coexist together. The phenomena observed by the team matched with the theoretical model developed by Professor Lado, showing that the researchers can fully control the quantum phenomena in their designer hybrid system. “This experiment demonstrates that graphene can simultaneously host the necessary ingredients for topological superconductivity. While in the current experiment we have not yet observed topological superconductivity, building on top of this experiment we can potentially open a new pathway towards carbon-based topological qubits,” says Prof. Lado.

The demonstration of Yu-Shiba-Rusinov states in graphene is

the first step towards the ultimate development of graphene-based topological qubits. Carefully controlling these states can create topological superconductivity and Majorana states. Topological qubits based on Majorana states can potentially drastically overcome the limitations of current qubits, but the emergence of these unconventional states requires meticulous control of the system parameters. The current experiment establishes the critical starting point towards this goal, which can be built upon to hopefully open a disruptive road to carbon-based topological quantum computers.

Published: 28.4.2021
Matthew Allinson

Citation

[Observation of Yu-Shiba-Rusinov states in superconducting graphene.](#)

Río, E., J. L. Lado, V. Cherkov, P. Mallet, J. Y. Veuillen, J. C. Cuevas, J. M. Gómez-Rodríguez, J. Fernández-Rossier, and I. Brihuega. 2021. *Advanced Materials*.

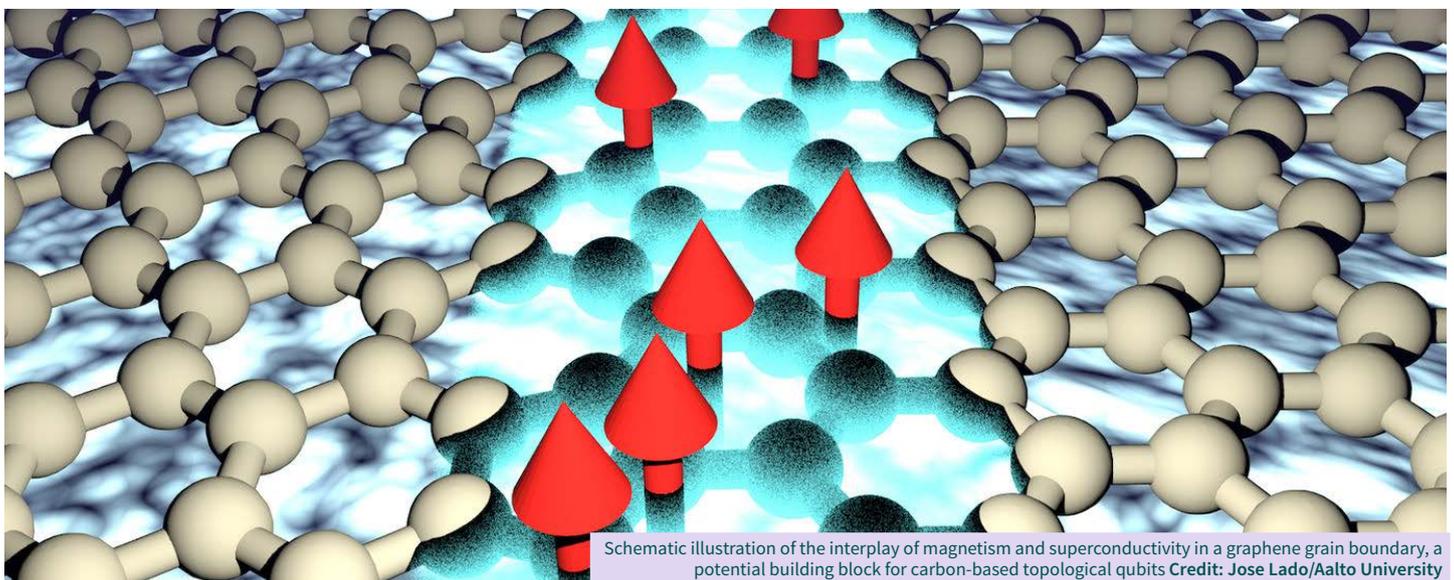
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New nanoscale device for spin technology

Spin waves could unlock the next generation of computer technology, a new component allows physicists to control them

Traditional electronics use electrical charge to carry out computations that power most of our technology. However, engineers are unable to make electronic calculations much faster: moving charge creates heat, and we can't make chips any smaller or faster without overheating. This is where spintronics comes in.

Like charge, spin is a property of particles that can be used to carry out computations, but it avoids the heating issues of current computer chips. The NanoSpin group at Aalto University, led by **Prof. Sebastiaan van Dijken**, studies how waves of spins can be used to transfer information, so heat is not created. His team made a spin-wave version of a Fabry-Pérot resonator, a well-known tool used in optics for creating beams of light with a tightly controlled wavelength. This novel device allowed them to control and filter waves of spin in devices that are only a few hundreds of nanometres across.

The device was made by stacking very thin layers of materials with exotic magnetic properties, which allowed the spin waves to be trapped and cancelled out if they weren't of the desired frequency. This novel concept is easy to imple-

ment: "The trick is to make good quality materials, which we are able to do at Aalto," explains Academy Fellow **Dr. Huajun Qin**.

Spin waves can be used to overcome the energy-costly conversion of wireless signals from higher to lower frequencies. Since they can operate at the microwave frequencies used in mobile phones and wifi signals, they can potentially be used to increase the speed and reliability of wireless communication technologies. Similarly, they can be used to increase the computational speed compared to electronic computing, which uses "Boolean" logic to do calculations. Spin waves carry information in the amplitude or phase of the wave, hence using an analogue "non-Boolean" style of computing that is beneficial for specific tasks like image processing or pattern recognition. Prof. van Dijken notes that the size structure of the Fabry-Pérot resonator makes it easy to integrate the system into existing technology.

Equipped with the resonator to filter and control the spin waves, the next steps are to make a complete magnetic circuit for them. This requires the ability to guide the spin waves towards functional com-

ponents, similar to electrical interconnects in electronic microchips. "We are looking at making similar structures to steer spin waves," explains Dr. Qin.

Funding: Academy of Finland, German Research Foundation. Device fabrication was carried out at OtaNano.

Published: 16.4.2021
Matthew Allinson

Citation

[Nanoscale magnonic Fabry-Pérot resonator for low-loss spin-wave manipulation.](#)

Qin, H., Holländer, R.B., Flajšman, L., Hermann, F., Dreyer, R., Woltersdorf, G. and van Dijken, S., 2021. *Nature Communications*, 12: 1-10.

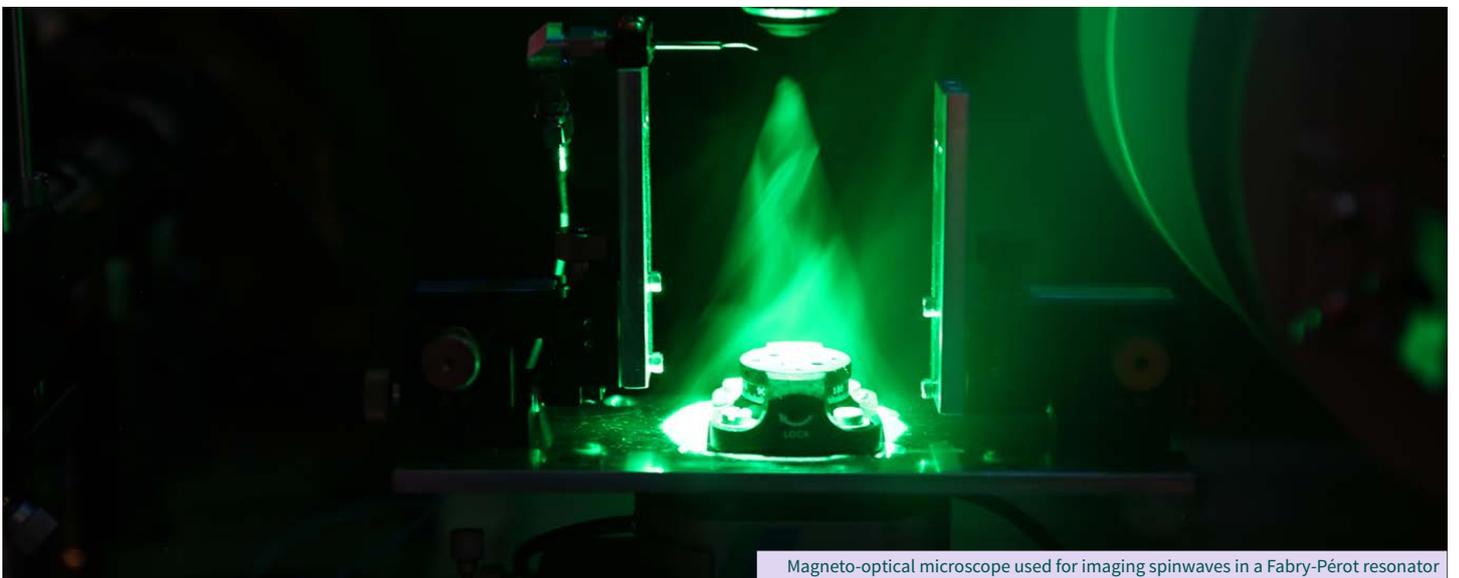
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Magneto-optical microscope used for imaging spinwaves in a Fabry-Pérot resonator

Evading the uncertainty principle in quantum physics

In quantum mechanics, the Heisenberg uncertainty principle dictates that the position and speed of an object cannot both be fully known at precisely the same time. Researchers from Aalto used vibrating drumheads prepared in a quantum state that, for the first time, evades the uncertainty principle

In quantum mechanics, the Heisenberg uncertainty principle is a fundamental concept which dictates that the position and speed of an object cannot both be fully known precisely at the same time. In the quantum world, particles like electrons can behave like waves, which means they cannot have a well-defined position and momentum simultaneously. For instance, measuring the momentum of a particle leads to a disturbance of position, and therefore position cannot be precisely defined.

Recent research led by **Prof. Mika Sillanpää** (Aalto University) has shown how to get around the uncertainty principle. Instead of elementary particles, the team carried out the experiments using much larger objects: two vibrating drumheads one-fifth of the width of a human hair. The drumheads were carefully coerced to exhibit a collective quantum motion. **Dr. Laure Mercier de Lepinay** explains that by vibrating in an opposite phase to each other, the quantum uncertainty of the drums' motion is cancelled if the two drums are treated as one quantum-mechanical entity.

This allowed the researchers to simultaneously measure the position and the momentum of the two drumheads – which should not be possible according to the Heisenberg uncertainty principle. Breaking the rule allows them to be able to characterise extremely weak forces driving the drumheads. “In addition to providing a novel technique for evading limitations imposed by the uncertainty principle, this experiment provides the most direct demonstration of long-lived quantum entanglement between macroscopic objects,” says **Dr. Matt Woolley** (University of New South

Wales), who developed the theoretical model for the experiment.

Entangled objects cannot be described independently of each other, even though they may have an arbitrarily large spatial separation. Entanglement allows pairs of objects to behave in ways that contradict classical physics, and is the key resource behind emerging quantum technologies. In macroscopic objects, quantum effects like entanglement are very fragile and are easily destroyed by any disturbances from their surrounding environment. Therefore, the experiments were carried out at a very low temperature, only a hundredth of a degree above absolute zero at -273 degrees.

In the future, the research group will use these ideas in laboratory tests aiming at probing the interplay of quantum mechanics and gravity. The vibrating drumheads may also serve as interfaces for connecting nodes of large-scale, distributed quantum networks.

Sillanpää's group is part of the national Centre of Excellence,

Quantum Technology Finland (QTF). The research was carried out at OtaNano.

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Matthew Allinson

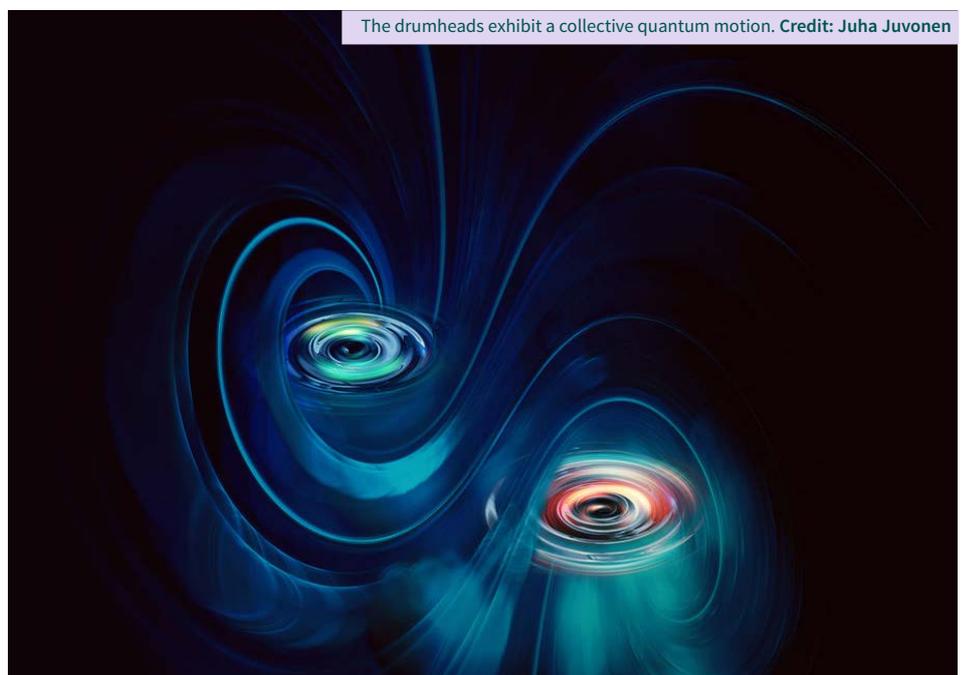
Citation

[Quantum mechanics–free subsystem with mechanical oscillators.](#)
de Lépinay, L.M., Ockeloen- Korppi, C.F., Woolley, M.J. and Sillanpää, M.A., 2021. *Science*, 372:625-629.

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The drumheads exhibit a collective quantum motion. Credit: Juha Juvonen

A new form of carbon

Not graphene: researchers in Germany and Finland discover new type of atomically thin carbon material

Carbon exists in various forms. Along with diamond and graphite, there are recently discovered forms with astonishing properties, such as graphene, which is the thinnest known material – just one atomic layer thick. Its unusual properties make it an extremely exciting candidate for applications like future electronics and high-tech engineering. The carbon atoms in graphene are linked to form hexagons arranged like a honeycomb. Theoretical studies have predicted that carbon atoms can also arrange in other flat network patterns, but these networks had never been realized until now.

Researchers in Germany and Finland have now discovered a new carbon network – named *Biphenylene* – that is atomically thin like graphene, but made up of squares, hexagons, and octagons forming an ordered lattice. This new material is made by assembling carbon-containing molecules on an extremely smooth gold surface. These molecules first form chains that are *chiral*: they exist in two mirroring types. Only chains of the same type aggregate on the gold surface,

forming well-ordered assemblies, before they connect. This unique structure was confirmed using high-resolution scanning probe microscopy, which also revealed that its electronic properties differ from those of graphene.

Unlike graphene and other forms of carbon, the *Biphenylene network* has metallic properties. At small sizes, graphene is only a semiconductor. However, narrow stripes of the network, only 21 atoms wide, can already behave like a metal. **Prof. Michael Gottfried** (University of Marburg), who leads the team that developed the idea, explains that these stripes could be used as conducting wires in future carbon-based electronic devices. Lead author **Qitang Fan** further highlights biphenylene's use as an anode material that could increase the storage capacity of lithium-ion batteries.

Prof. Peter Liljeroth's (Aalto University) group carried out the high-resolution microscopy that showed the material's structure, while **Prof. Adam Foster's** (Aalto University) team used computer simulations and analysis to under-

stand the exciting electrical properties of the material.

The teams continue to work on producing larger sheets of the material, so that its application potential can be further explored. Prof. Liljeroth points out that this new synthesis method can also lead to the discovery of other novel carbon networks.

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Matthew Allinson

Citation

Biphenylene Network: A Nonbenzenoid Carbon Allotrope.

Q.T. Fan, L.H. Yan, M.W. Tripp, O. Krejčí, S. Dimosthenous, S.R. Kachel, M.Y. Chen, A.S. Foster, U. Koert, P. Liljeroth, J.M. Gottfried. 2021. *Science*, 372

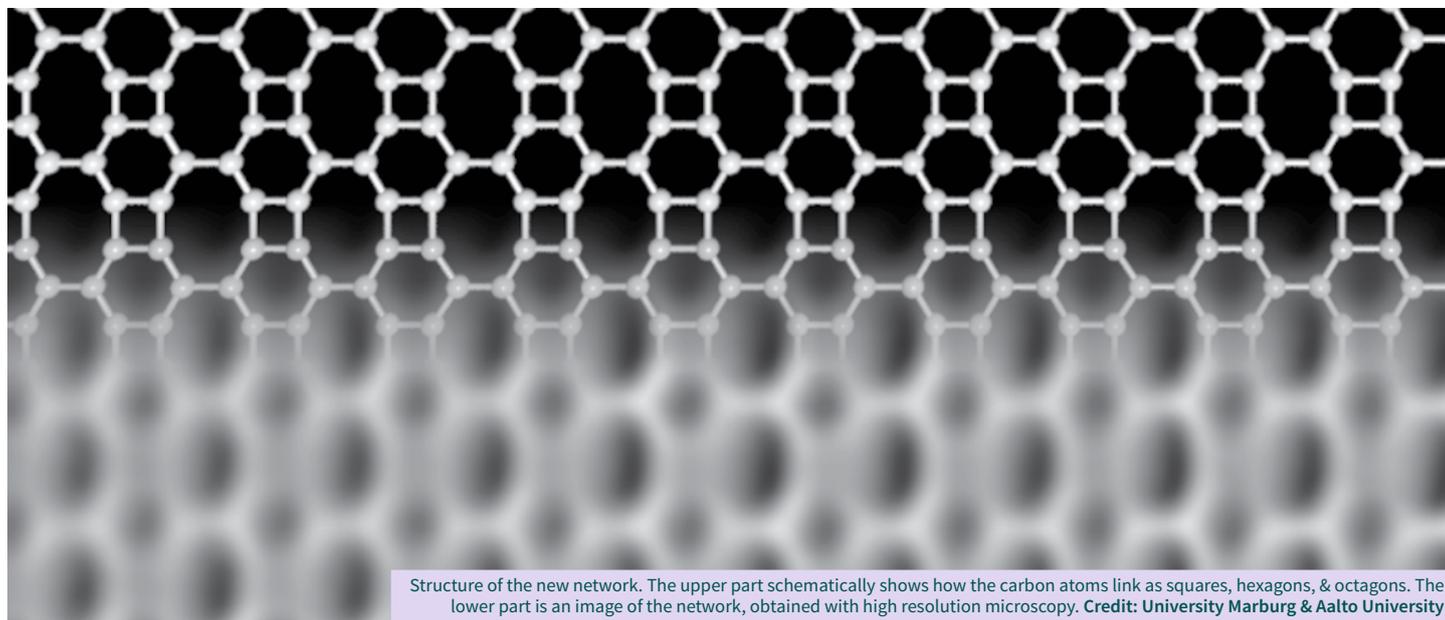
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Structure of the new network. The upper part schematically shows how the carbon atoms link as squares, hexagons, & octagons. The lower part is an image of the network, obtained with high resolution microscopy. Credit: University Marburg & Aalto University

This year's publications:

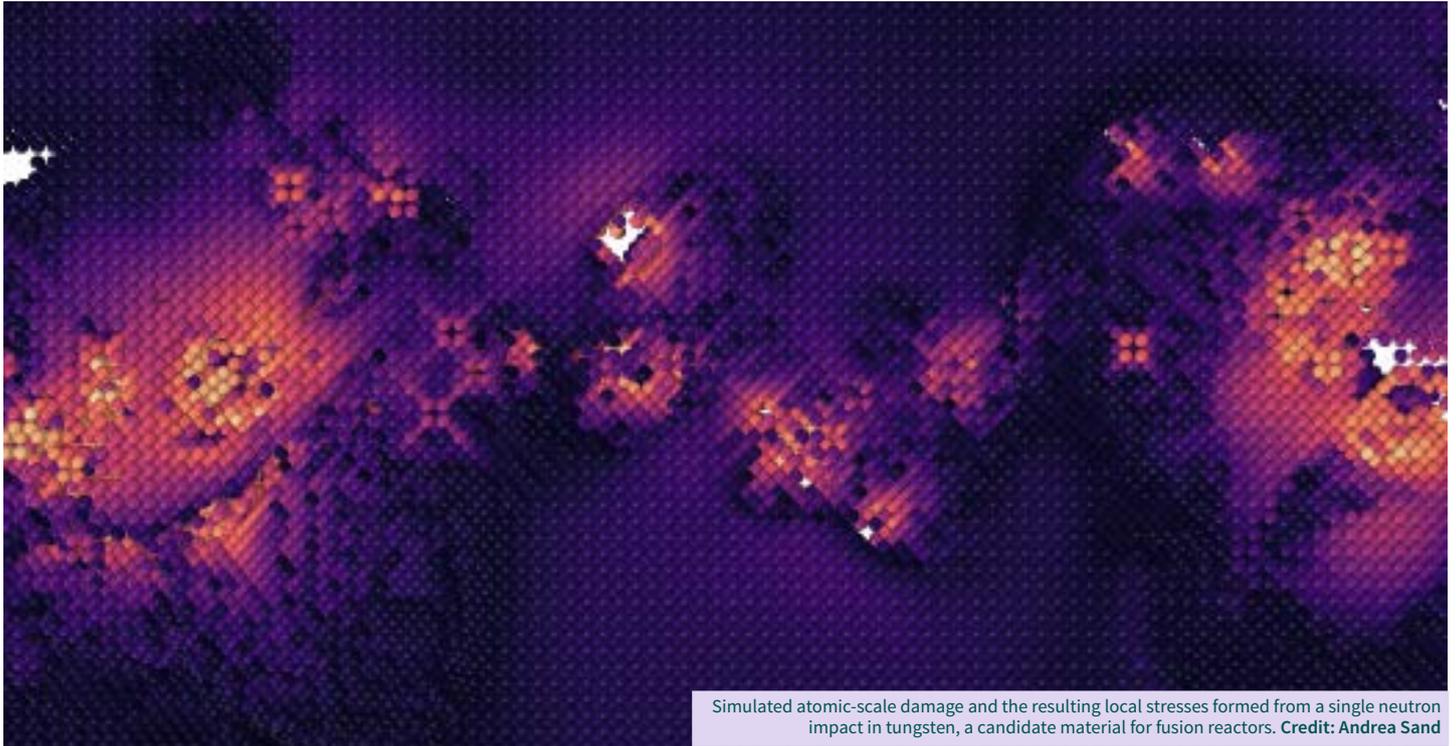
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Simulated atomic-scale damage and the resulting local stresses formed from a single neutron impact in tungsten, a candidate material for fusion reactors. Credit: Andrea Sand

Assistant Professor Andrea Sand joins the Department of Applied Physics to lead the Nuclear Materials and Engineering group

Her research uses computer simulations to understand how radiation affects materials.

Radiation damage is important to study because over time, radiation changes materials' properties, for example affecting their thermal conductivity and brittleness. Since the processes that cause radiation damage are so fast and happen in extreme situations, it is very difficult to observe them directly or safely recreate the unique environments with regular experiments. So, to understand the processes and predict the possible effects, her team will model them using computers.

Her main focus is on future applications of materials in which radiation will be a key part, including nuclear fusion and the next generation of nuclear fission. Although the

materials in existing fission reactors are available to examine radiation damage, this is not the case for next generation reactor designs, so simulations are important in designing them. She has recently become interested in how radiation affects semiconductors, which is relevant for improving the radiation damage-resistance of electronics on spacecraft, and also for increasing the sensitivity of low-temperature particle detectors.

The radiation responses of materials is a big constraint on future energy technologies. By tackling the issues pertaining to safety and commercial feasibility, nuclear energy from fission and fusion will be able to both meet the growing energy demand while also combating climate change. Moreover, nuclear energy suffers from serious stigma

because of historical missteps and a fear of the unknown. Prof. Sand hopes to mitigate some of the fears concerning radiation and help society recognise nuclear energy as a clean and practically infinitely abundant energy source.

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Finnish Quantum Institute will coordinate research, education and innovation across Finland

Aalto University, University of Helsinki and VTT Technical Research Centre of Finland have signed an agreement to collaborate on quantum science and technology, under the umbrella of **InstituteQ: The Finnish Quantum Institute**. All three of the founder institutions have decades of experience in the research, teaching and commercialisation of quantum science and technology. By joining forces through InstituteQ, the parties aim to keep Finland and Europe at the forefront of an increasingly competitive global field.

Acting director **Prof. Jukka Pekola** (Aalto University) describes the three goals: “to coordinate our national research efforts; to provide the best possible education, both in graduate and industrial programs; and to drive innovation.” **Prof. Sabrina Maniscalco** (University of Helsinki) explains how by combining and coordinating resources, expertise will be developed in new directions and hence overcome the major bottleneck in developing quantum

technology. **Dr Himadri Majumdar** (VTT) further identifies the exponential and sustainable growth opportunities in quantum technologies for the future.

‘Quantum technology’ is the application of phenomena that arise from the unique behaviour of quantum physics. Quantum computers, quantum networks and quantum sensors are becoming a reality. They have the potential to massively disrupt humanity’s ability to process information and, over time, our everyday lives as well. Applications range from high performance computing to secure telecommunications and from chemistry/medicine to energy. This year, among other things, we will see the completion of the first phase of a quantum computer, co-developed by VTT and a Finnish start-up IQM.

“In Finland, we already have a strong environment for quantum technology, such as the OtaNano research infrastructure and the QTF Centre of Excellence” Prof. Pekola says. “We want the Institute

to guide the development of current infrastructure, and have a role in generating new pathways and projects for quantum technologies.

Further reading: [Quantum Literacy for All](#)

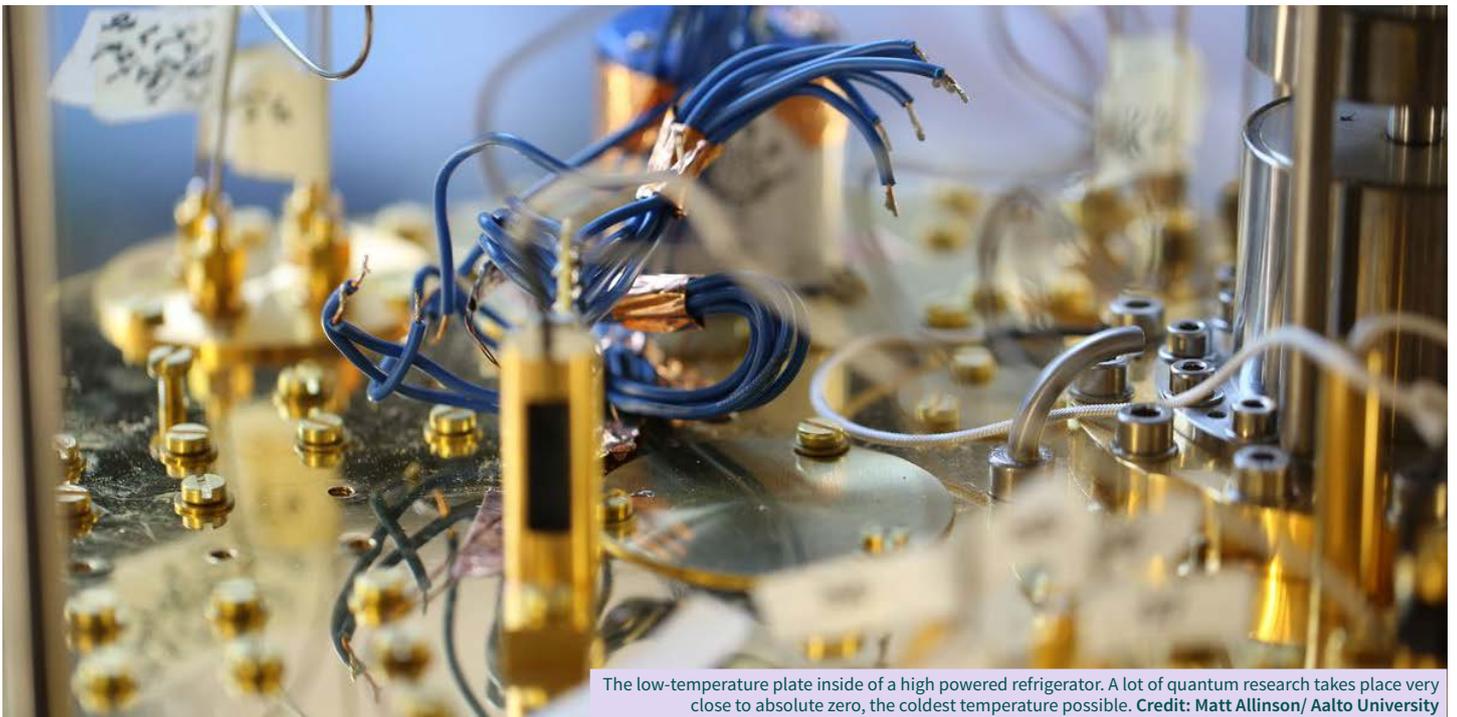
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The low-temperature plate inside of a high powered refrigerator. A lot of quantum research takes place very close to absolute zero, the coldest temperature possible. Credit: Matt Allinson/ Aalto University

Awards, prizes & funding

New funding to commercialise high-tech liquid-repelling coatings



Recently, researchers from Aalto made superhydrophobic surfaces that are strongly resistant to damage. The result, published on the front cover of the journal *Nature*, was a major breakthrough; until now, extremely water-repellent surfaces have been too delicate to be used widely. The team was able to apply an extremely water repellent coating to hard materials, like ceramic and glass.

The team recently secured two blocks of funding covering both research and commercialization efforts during 2021–2024. The first block of funding from Business Finland will support research on how

the superhydrophobic coatings can be applied to flexible, plastic materials. These could have applications in products such as weather-resistant plastic casings for sensors on the outside of houses, or coatings to be applied to the bottom of skis to reduce friction. The second block of funding from Future Makers will support research into applying the ARMOR coating to hard materials like glass and wood.

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Matthew Allinson

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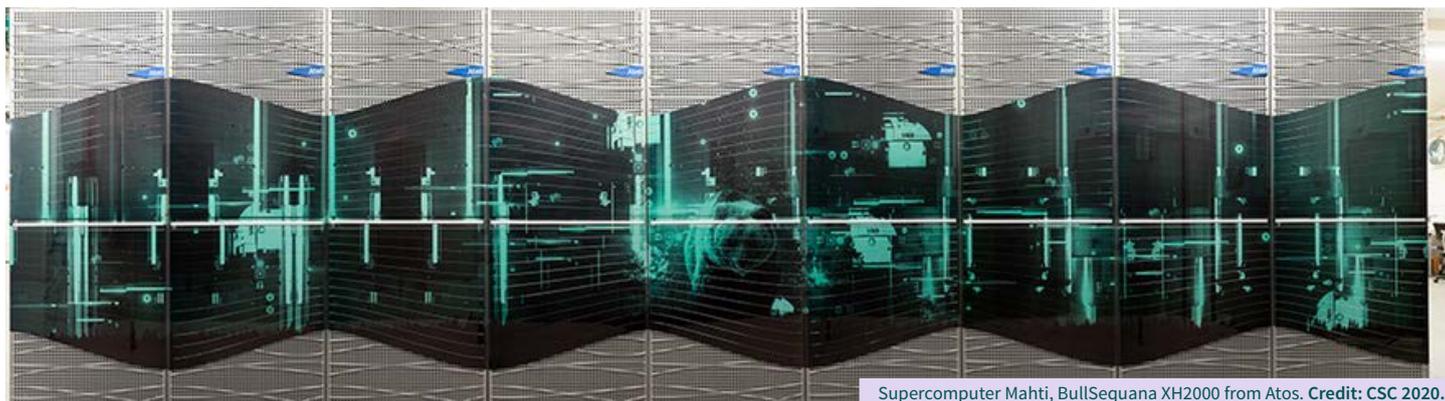
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Researchers from CEST awarded a competitive Grand Challenge project on Mahti



Milica Todorović and **Patrick Rinke** will manage a 15 million core-hours project “*Active machine learning methods for atmospheric science applications*” in a cross-disciplinary collaboration with **Dr. Theo Kurtén** and **Prof. Hanna Vehkamäki** (Uni-

versity of Helsinki). Active learning dataset curation techniques, developed by **Kunal Ghosh** at CEST, will be employed to optimize the quality of machine learning of aerosol condensation properties for small atmospheric molecules. This is im-

portant information for atmospheric climate models that shape public policy on climate change.

Published: 8.1.2021
Bernadette Gehl-Väisänen

Computational physicist Dorothea Golze receives prestigious Emmy Noether Award to establish her own junior research group at the Technical University of Dresden

Golze's Emmy-Noether project will develop highly accurate theoretical methods for core-level spectroscopy of complex materials based on fully relativistic Green's function theory in the GW approximation. The project will focus on X-ray photoelectron spectroscopy (XPS) and X-ray absorption spectroscopy (XAS), which are powerful tools for materials characterization. However, the experimental spectra are generally difficult to interpret without aid from predictive theoretical models. The goal of the Emmy-Noether project is to advance highly

accurate GW-based methods for the prediction of XPS and XAS of complex materials, including light and heavy elements. The project will push GW-based methods to previously inaccessible system sizes by developing low-scaling algorithms and exploiting the computational power of the new generation of exascale supercomputers.

Published: 20.1.2021
Bernadette Gehl-Väisänen



Aaro Väkeväinen and Lauri Himanen win School of Science Dissertation Award

Aaro Väkeväinen's (Quantum Dynamics group) dissertation demonstrated strong coupling between light and organic dye molecules in plasmonic nanoparticle arrays, which ultimately led to observation of Bose-Einstein condensation (BEC) of strongly coupled lattice plasmons. These pioneering results were achieved only by overcoming many experimental challenges. Remarkably, the strongly coupled BEC is formed at record speed of only about 100 femtoseconds at room temperature, and hence required a special measurement technique which Väkeväinen developed. The results are of high scientific interest as the BEC offers a new platform for studies of non-equilibrium quantum phenomena, at room temperature. As the BEC emits a bright light beam with highly tunable properties, applications in future optical and quantum technologies are also possible. During his studies he published five research articles, two of which as first author, in esteemed journals including *Nature Communications*, *Nano Letters* and *Nature Physics*.

Lauri Himanen's (CEST/SIN Group) dissertation reviews how data-driven approaches can be used to augment materials research, focusing on two key areas: using data-driven design and tools to re-imagine the life-cycle of materials data, and using **machine learning** to complement existing research methodologies in materials science. The dissertation introduces **novel tools for automated materials data mining** and software for converting material data into an efficient input for use in machine learning. The effect of such data-driven techniques is demonstrated by applying them in finding optimal coating materials for perovskite-based photovoltaics using data mining and using machine learning for identifying catalytically active sites on nanoclusters. His studies included a review article that was among the top 10% most downloaded papers of *Advanced Science* in the first year following online publication, highlighting the impact and timeliness of this research.

Lauri is currently a Materials Informatics Specialist at the Fritz-Haber-Institute of the Max-Planck-Society in Berlin, Germany.



Aaro Väkeväinen
Credit: Lauri Lehtola



Lauri Himanen

Published: 5.5.2021
Bernadette Gehl-Väisänen

Professor Peter Lund receives the Jiangsu International Science and Technology Cooperation Award

The recognition was granted for his contribution into the development of renewable energy, and for developing cooperation between the European Union and China. The cooperation has led to significant results in the development of solar energy, fuel cells, energy storage, and energy systems. Jiangsu Province, known for its research into clean energy and artificial intelligence, will have a central role in China's coming energy transformation aimed at achieving carbon neutrality in 2060.

"China is one of the world's leading countries in clean energy. It is also embarking on a great leap forward in the reduction of emissions. Therefore, it is a most interesting case for researchers in the field," says **Prof. Lund**, who holds an honorary professorship at Southeast University in Jiangsu Province.

Prof. Lund also won the Best Research Article Award 2020 in *Technology*.

Published: 27.1.2021
Tiina Aulanko-Jokirinne



credit: Anni Hanén

Levi Keller wins Finnish Cultural Foundation award for doctoral studies on developing computational methods for spectroscopy

Levi Keller from the CEST group won a Finnish Cultural Foundation Award for his doctoral studies, which use the intersection of computational science and spectroscopy studies to relate experiment to theory. Spectroscopic experiments allow the observation of addition and removal energies of electrons in materials, which often contain partially overlapping features and complex satellite structures. The ability to accurately calculate these energies is critical to their interpretation, but has remained limited for example by the high computational ex-

pense and poor scaling of the common GW approximation method. Levi's grant will be used to develop an embedding scheme for the GW approximation, which will extend the highly accurate quantitative interpretative capability already attained for gas-phase molecules to entirely new classes of extended systems. These predictions provide fundamental insight into the structural, chemical and electronic properties of materials.

Published: 23.2.2021
Bernadette Gehl-Väisänen



Mika Sillanpää awarded €2.5M to support work reconciling quantum mechanics and general relativity

With funding from a competitive ERC Advanced Grant, **Prof. Mika Sillanpää's** team will try to solve a hundred-year-old mystery of physics: the incompatibility of the general relativity and quantum mechanics. The QUANTUM project aims to determine the effect of gravity on the quantum-mechanical states and vibrations of two gold spheres at extremely low temperatures. This is an extremely closed system where phenomena unseen in classical physics may occur. In the first phase, the researchers aim to measure the gravitational force itself between the masses weighing a milligram. Gravitational forces have never been detected experimentally between masses even close to such a small size, and it is not clear whether the normal law of gravity applies at such a small scale. Next, they will identify gravity in a situation where internal quantum indeterminacy of the gold spheres dominates their vibration. In the final stage, they will try to verify a genuinely quantum state – entanglement

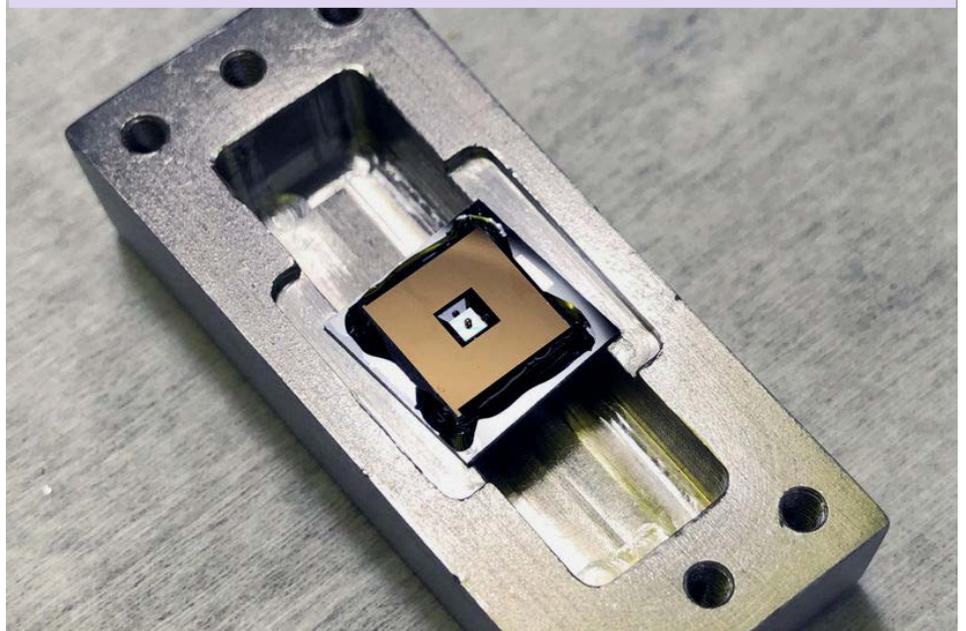
– alongside gravity.

The project uses the OtaNano national research infrastructure. Part of the ERC funding goes to the purchase of a new cryostat, or dilution refrigerator, manufactured by a Finnish Aalto -spinoff company Bluefors specialised in delivering instrumentation for quantum technology. The field of Quantum

mechanics contributes to technological advances such as precision measurements, and quantum information, which will be important for the next generation of computers. This will be the third ERC grant Sillanpää has received.

Published: 22.4.2021
Bernadette Gehl-Väisänen

In the experiment, both gold spheres rest on a very thin membrane so that the spheres are close to each other but free to vibrate. A small gold sphere on a membrane is visible in the center of the image. credit: Aalto University



CTO Forum names Mikko Möttönen as Innovation Professor of the year

Prof. Mikko Möttönen wins the new award category of Innovation Professor of the Year for his theoretical and experimental research on quantum information.

The Innovation Professor of the Year Award was given by Technology Industries of Finland, Business Finland and the innovation consulting company Spinverse to highlight the importance of Möttönen's work on the future competitiveness of Finnish industry. "The collaboration between companies and universities is at its best in ecosystems led by companies and where the professors have the full support of their

organisation for the activities," explains **Nina Kopola**, Director General and CEO of Business Finland.

Prof. Möttönen is head of the [Quantum Computing and Devices research group](#) that is a part of the Academy of Finland Centre of Excellence in Quantum Technology (QTF). He holds a joint professorship in the Department of Applied Physics at Aalto University and VTT Technical Research Centre of Finland, and is also one of the four founders and Chief Scientist of [IQM Finland](#).



credit: IQM Quantum Computers

Published: 17.2.2021
Matthew Allinson

Grazia Salerno awarded prestigious Marie Curie Action Individual Fellowship for TEBLA

Controlling and manipulating quantum matter is a fast-growing research topic that could influence many aspects of our daily life with a new technological paradigm. A promising step in this direction is to use topology – the study of quantities that are preserved under deformations – to tune the physical properties of matter. The discovery of topological insulators has given hints of novel possibilities to design a generation of fault-tolerant devices,

that are unaffected by defects or perturbations. However, a lot more needs to be uncovered in topological quantum many-body systems at a fundamental level to achieve this. **Dr Grazia Salerno** will study how topology affects collective phenomena such as lasing. The project focuses on topological lasing in nanoscale photonic systems: this could lead to new miniaturized light sources with bright coherent beams whose important properties are

made particularly robust by utilizing topological concepts. The work is theoretical, and will be directly relevant for the experiments performed in the host group (Academy **Prof. Päivi Törmä**), so any new findings can be readily tested.

Published: 23.3.2021
Matthew Allinson

Young Researcher Entrepreneur 2020 Award

Academy Research Fellow Kuan Yen Tan and **Jan Goetz** win The Young Researcher Entrepreneur 2020 Award for co-founding IQM Quantum Computers. The company builds quantum computers based on superconducting technology. These computers hold great promise

for taking only minutes to solve certain complex tasks that would otherwise take thousands of years to compute on a regular computer. IQM provides quantum computers to universities and research centers for scientific and educational purposes. The company has raised

71 million euros in funding, and in November 2020 it landed a contract with VTT to build Finland's first quantum computer.

Academy of Finland 2020 call

Projects

Professor **Pertti Hakonen** will investigate helium-carbon nanotube systems, aiming to bring new understanding to the interplay between topology and point defects. The work focuses on topologically frustrated states created in carbon nanotubes. Understanding and improved control of such system can open a door to new superconducting systems.

Professors **Robin Ras** and **Heikki Nieminen** aim to quantify fast mechanical phenomena taking place in interactions of thin gas layers in liquid and ultrasound. Broadening the understanding and developing models to better control these phenomena may enable development of novel industrial and medical applications in the microscale.

Professor **Patrick Rinke** will develop a new green and cost-efficient biorefinery concept for a range of high-value applications like carbon fibers, thermoplastics and 3D objects. The research results will establish a roadmap for adoption of wood-derived products in these advanced applications. Artificial intelligence (AI) methods will be used for the optimal processing conditions and thus, to identify promising new investigation routes. The project is led by **Mikhail Balakshin** (Aalto University).

Assistant Professor **Jaakko Timonen** aims to improve the current understanding of the complicated physical and chemical behaviours of oil-based colloids in electric fields. Dispersions of small particles in liquids are examples of colloidal matter. Colloids are very important and ubiquitous around us, including many food items (milk, cream), paints and even bio-

logical fluids. Timonen will develop and use a new, powerful, scientific methodology for studying electric phenomena in oil-based colloids by combining electric measurements with direct imaging using advanced optical microscopy techniques.

Research Fellows

Manohar Kumar will probe exotic particles called non-Abelian anyons in graphene. These particles have a memory of their quantum states, which means they can be used to store and process quantum information.

Ivan Lomakin's project aims to develop advanced techniques for 3D atomic data reconstruction. A mathematical model of the dynamic system will be built from measured data using statistical approaches and advanced computational techniques including machine learning algorithms. This will provide new information about high-entropy and amorphous alloys to disclose their microstructure and properties.

Kezilebieke Shawulienu's project focuses on the fabrication of van der Waals (vdW) materials and their heterostructures with atomically well-defined and controlled interfaces. The ability to understand and manipulate electronic phenomena at the quantum level will help create designer materials with new exotic properties. A promising solution to these problems lies at the interface of condensed matter physics and material science.

Postdoctoral Researchers

Zoran Cenev's project aims to develop a new printing method for

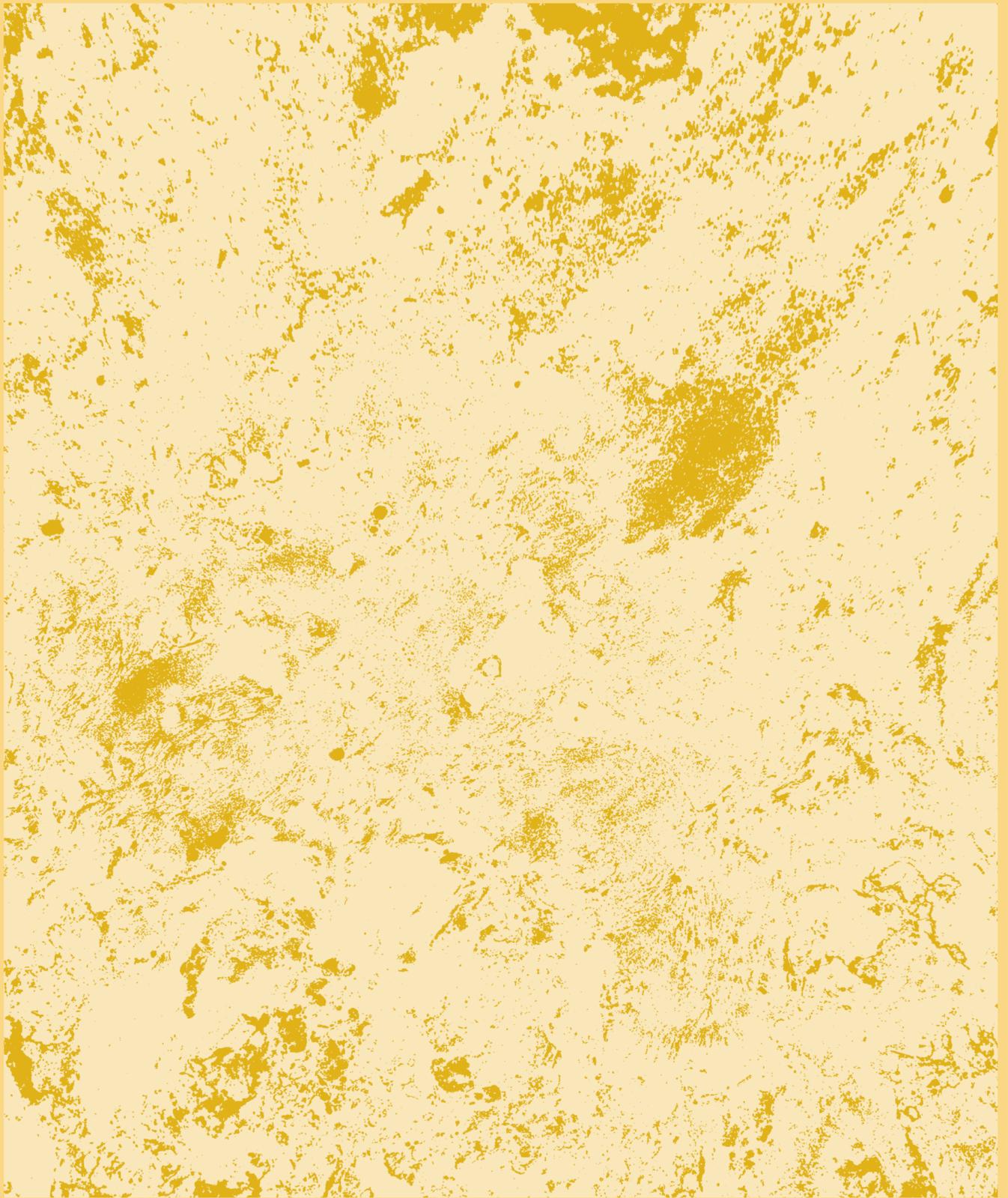
producing 2D/3D objects using aerosolized particles and a focused laser beam. This will allow for printing of 2D or 3D objects with sub-micron resolution, which is far beyond what is currently available.

Lukáš Flajšman's project "*Bridging Magnons*" develops new techniques for exploiting the phenomena of spin waves in materials. Mobile phone and WiFi technology rely on microwave processing, and the components developed in this project could potentially enable much smaller and more powerful devices.

Laure Mercier de Lepinay's project "*Vacuum forces between superconductors probed with microwave optomechanics*" aims to explore the incredibly small forces that quantum fluctuations exert on materials. These forces have been measured before, but never using superconducting materials, and Dr Mercier de Lepinay hopes that doing so will shed more light on the phenomenon.

Carlo Rigoni is looking to create a new class of synthetic materials that could behave biologically. The project "*Dissipative functional nanomaterials with non-equilibrium magnetic and photonic responses*" will try to make nanomaterials with structures that can be controlled via energy dissipation.

Owies Wani is producing new materials inspired by "homeostasis – nature's ability to resist changes imposed by the environment. He will produce a resilient and interactive material that, if strained under load, would have an inbuilt mechanism to return to its initial state and thereby maintain its integrity. This will potentially be useful for the emerging field of soft-robotics.



RESEARCH SPOTLIGHTS

Research Groups

Complex Systems and Materials (CSM)

Group leader: Professor Mikko Alava

Established around 1999, when COMP Center of Excellence version 1.0 started. We have a spin-off group in Poland (nomaten.ncbj.gov.pl), where I (Prof. Alava) split my time as the director of the Center of Excellence NOMATEN (see a pattern?). This should lead to funny synergy effects.

Current members include 1 research fellow, 1 senior postdoc, 3 postdocs, 4 PhD students, 1 industrial designer, 2 civil service workers, 2 undergraduates.

What are the central questions that your research aims to answer?

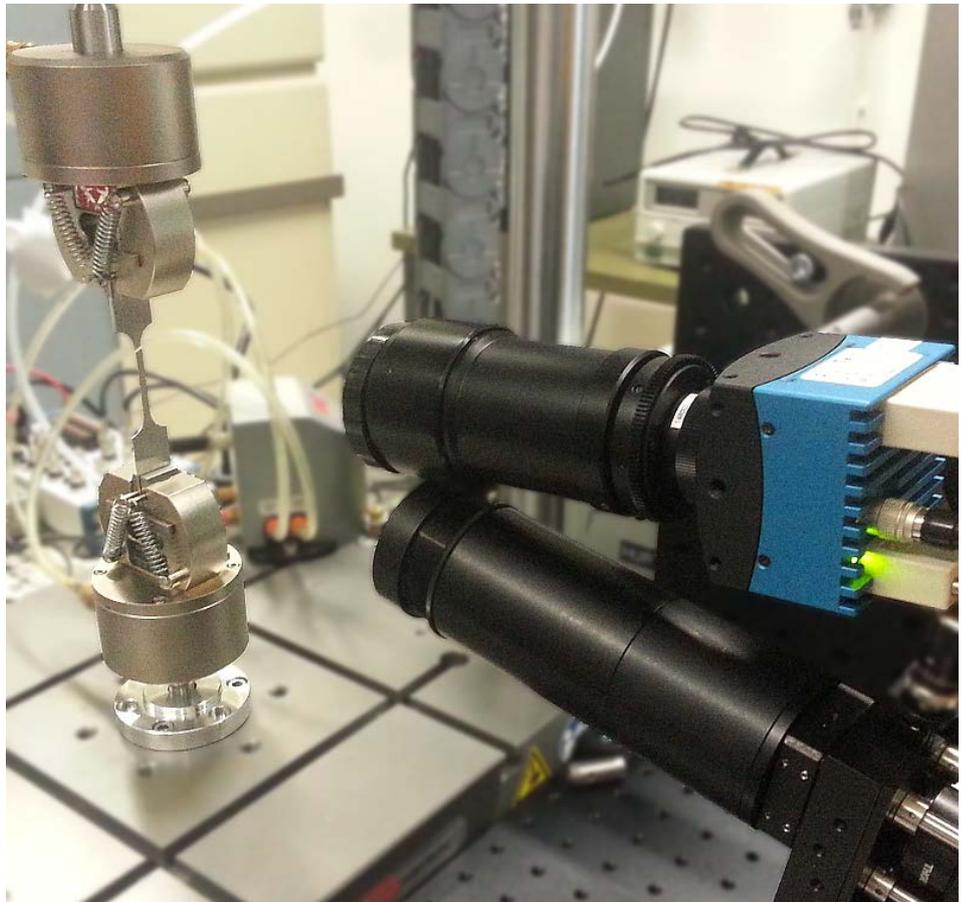
We look at how matter behaves. How does it deform, break, yield? Can we design materials? We do experiments and models. We also have a close and longstanding connection with computer science, which means High-Performance Computing and Machine Learning lately.

What methods/approaches do you use to answer these questions?

Experiment, theory, simulations.

Why is this research important? How are people outside the scientific community affected by your research?

For the past 20 years we have strived to understand engineering by physics. This means that we have to do experiments to have a physicist's view (how does paper break or wood deform?); we have to develop new paradigms of theory using statistical mechanics and multiscale modelling; and finally we have to



apply all this. What you learn doing this is a cross-disciplinary view of physics and applications so you may apply these skills also outside of physics: data, analysis, common sense. We also look for commercial applications. For example, Juha Koivisto's start-up CleanDet Ltd dealing with dirt detection on surface with Machine Learning and hyperspectral imaging, and our recent advances in biofoams (Foamwood, or "Älyä Vaahtoihin" by the Future Makers -program).

Biggest achievement:

Making a flight back home from Milan about 10 years ago. Four people in a small car, it was snowing and

we were late.... we had an Alfa Romeo so it was easy.

Fun fact: tell us something about your group that most people don't know

The group social tradition is the card game of Koira (the Dog), thanks to Vilho Petäjä (PhD at CSM, 2006). It leads to phase separation – you play or you watch.

Quantum Nanomechanics (NEMS)

Group leader: Associate Professor Mika Sillanpää

Established in 2010, in the Low Temperature Laboratory, which was a separate department that later merged with DAP.

Current members include 4 post-docs, 3 PhD students

What are the central questions that your research aims to answer?

Our work, primarily experimental, has some connection to Quantum Technology, but we are mostly interested in very fundamental questions. We want to understand what quantum mechanics can tell us about the motion of macroscopic objects. Very soon, we will embark an ambitious experimental project asking Mother Nature what happens when you try to create a quantum-mechanical system that has gravitational interactions inside it. I promise our results will NEVER be applied in mobile phones!

What methods/approaches do you use to answer these questions?

Our lab is in the OtaNano Low Temperature Laboratory, where we operate three dilution refrigerators that can reach ultralow temperatures below 10 milli-Kelvins. The samples are first fabricated in cleanrooms using micro fabrication. They are then measured in the dilution fridges using sophisticated microwave instrumentation. The experiments, in particular preparing for them, are difficult, but if (and usually when) it works, you will get a reward.

Even for (experi)mentalists, it is useful to occasionally do some semi-theoretical research, which can help to understand what one is actually doing in the lab. True hardcore theory, however, is left for the smarter people.

Why is this research important? How are people outside the scientific community affected by your research?

The product of fundamental research is knowledge, not a gadget. I wish this fact would be better appreciated at various levels of society. Besides the knowledge, applications sometimes arise from fundamental research although it may not be directed towards such. As an example, the now - famous Pfizer guy is being funded by ERC to investigate mRNA technology, and lo and behold what happened.

Outside the scientific community, the people under our influence consists of

1. the types of people who have read the book A Brief History of Time, and thus like to read about mysteries of quantum mechanics and stuff.
2. journalists who do not know what the word physics means.
3. about zero people applying our research findings for business.

Biggest achievement:

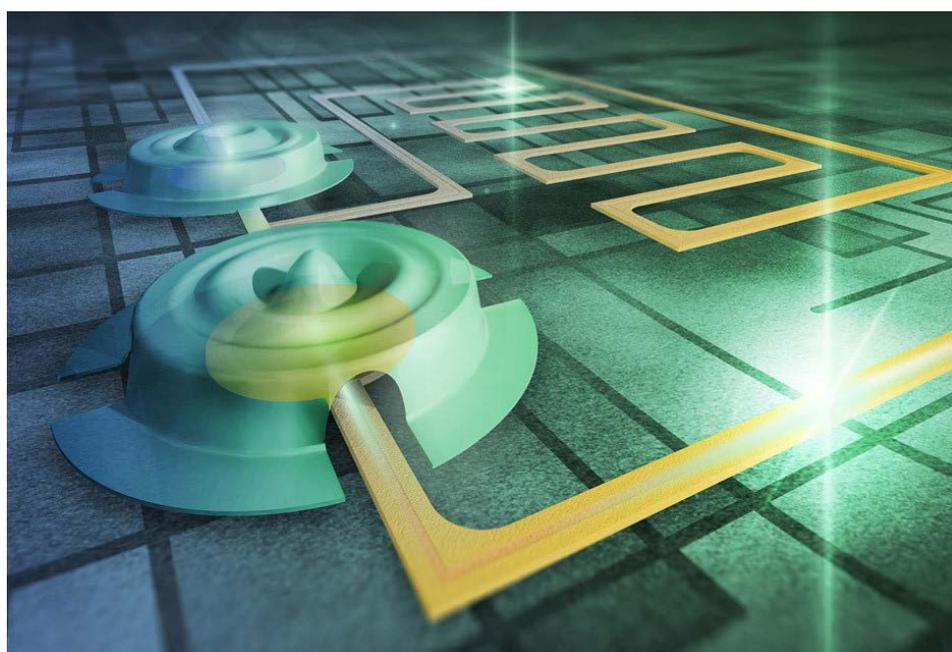
Keeping the lab clean for an entire week.

Fun fact: tell us something about your group that most people don't know

The boss likes occasional hands-on work in the lab, like collecting used paper towels lying on lab tables and putting them into trash cans.

When the group was smaller, we made a boat trip together, but now somebody needs to buy a bigger boat before boating can resume. No other solutions than a bigger boat is foreseen in the foreseeable future. Perhaps the department can raise the salaries so that we can reach the goal.

We own a microwave analyzer, which was bought as a demo unit at the cost of about 30 ke. The unit contains terribly many useless options meant for inventing mobile phones. We got a decent discount since we didn't need the extra crap: because of the Nokia-type options, the list price is 330 ke.



Researchers

Amina Chahla

BSc student

Which area of physics interests you the most?

I saw a movie called The Theory of Everything, which made me want to pursue physics. I would have said then that astrophysics interests me the most. But I don't know how I became interested in quantum technology – the opposite side of the spectrum. I fell into this rabbit hole and found quantum theory on the other side. I am deeply intrigued by the theory, by the philosophical side to it, by its multiple interpretations, etc.

Which skills have you developed the most during your studies? What are your main strengths?

Other than the technical skills that I got to hone via courses (e.g. programming), I would say time management, compartmentalization and prioritizing are the soft skills that I have developed the most. Studying at Aalto isn't very stressful, and Finland as a country, in my opinion, puts a great emphasis on tranquility and a peaceful way of living. Nonetheless, as a student with some overlapping courses, frequent deadlines and a desire to participate in activities, events and committees, it has become important to learn how to micromanage and prioritize tasks. However, I think my main strength lies in my attitude towards life, and the mantra of "I got this!"

Have your studies progressed as expected, or have you faced any unexpected challenges? If so, how did you overcome them?

Due to the pandemic, this past year has been difficult and extremely strange. Sure, remote learning provided some advantages such as a great flexibility in study times and the availability of recorded lectures. However, it proved to be a huge challenge. Motivation, commitment and discipline are harder to maintain when you don't attend lectures in real life. It was paramount that I kept to a certain schedule so I would not miss any deadlines. But in my opinion, what really made a difference and boosted my focus was to adapt to these strange times and use zoom as a platform to organize study sessions with my classmates, which allowed us satisfy our social needs and get some semblance of a normal student life (coffee also provided some much needed mental and physical support).

What are your career goals?

At this point in my journey, my career goals are still a little vague. When I started my studies, I was thinking of a getting a PhD and pursuing a career in academia, as research is what interests me the most. However, with the grossing demand in quantum technology and the founding of new companies that are interested in producing quantum computers, I am growing more open to the idea of working in the industrial sector.



Rebecca Heilmann

PhD student

Quantum Dynamics group

When did you join Aalto?

I came to Aalto as an exchange student in 2017, and decided to finish my Master's degree here. Since 2018, I have been a Doctoral Candidate in the Quantum Dynamics group under the supervision of Prof. Päivi Törmä.

What is the topic of your thesis?

I study plasmonic nanoparticle arrays, usually combined with organic dye molecules. In particular, I study phenomena such as strong coupling and lasing in these structures. What motivated you to study this topic?

I got hooked during my Master's thesis, and I wanted to continue to research that topic further. I am especially intrigued by possible applications of plasmonic nanoparticle arrays such as in biosensors or medical treatment, and it keeps me motivated that maybe someday my research could lead to new developments in these fields.

What are your most important findings so far? How do they fit into the "big picture"?

In my first project, we showed that organic dye molecules can form strong coupling with the lattice modes of a dielectric nanoparticle array. Strong coupling in plasmonic systems has led previously to lasing and condensation phenomena. Usually, plasmonic nanoparticle arrays consist of metals that have high absorption losses, whereas dielectrics offer low -dissipative

properties. This in turn can lead to narrower resonances, longer lifetimes of the modes and hopefully to lower thresholds in lasing and condensation phenomena. We also observed topological lasing in plasmonic nanoparticle arrays, which originates from a novel design of the lattice structure, but this project is still under progress.

Which skills have you developed the most during your studies? What are your main strengths?

Besides all the technical skills I need for the lab work and fabrication of my samples in the clean room, I think that my frustration tolerance improved a lot whenever experiments did not work out as planned or a tool I needed for fabrication was down. My main strengths include endurance, good time management, and empathy.

What aspects of your research do you enjoy the most?

Doing the experiments, fabrication of my samples and discussing results with my colleagues. I also really enjoy my teaching duties, although they are not directly related to my research.

Has your research progressed as expected, or has it taken some unexpected turns?

I think the most unexpected turn was the pandemic during which our lab was closed for several weeks - not so nice if you're an experimentalist. Otherwise, not really.



What are your career goals?

Currently, I would very much like to work as a university lecturer. I could also imagine continuing research with more focus on medical applications, either in industry or academia. But who knows, I still have about 1.5 years left of my doctoral studies and my plans can change during that time.

Ondřej Krejčí

Postdoc, Surfaces and Interfaces at the Nanoscale group

When did you join Aalto?

Early 2018

What is the topic of your research project?

I generally calculate atomic and electronic structure of surfaces and adsorbate on surface via Density Functional Theory and work on or develop simulations for various surface science experiments – mainly Scanning Probe Microscopy (SPM) and X-ray spectroscopies. A current topic is revealing the principle and creation of simulation software for Kelvin Probe Force Microscopy (KPFM) with flexible tip apices. Generally, SPM with flexible tip apices are one of the few non-invasive methods (I think it is the only one, but there are plenty of Microscopy techniques), which can distinguish single atoms even in organic molecule. See the next point for the rest of the story...

What motivated you to study this topic?

Physics: the book George Gamow Mr. Tompkins in Wonderland.

(Computational) Surface Science: meeting with my previous supervisor through my studies.

KPFM: I was the main programmer in development of simulation methods for other types of SPMs with flexible tip apices – Atomic Force Microscopy and Scanning Tunneling Microscopy. The Kelvin Probe is the last method, which is not well understood yet. It can give information about electrostatics, which can hopefully (and luckily) lead to chemical resolution.

What are your most important findings so far? How do they fit into the “big picture”?

In terms of publications/citations, those related to on-surface reactions

and their mechanisms or products (although it is highly unlikely that I will ever see application of these things in something you can buy during my lifetime). My most important contributions have been releasing and maintaining my own code. The related paper has been cited several times, and I know some people that are using the code and find it useful.

The biggest picture I have ever seen was the Slav Epic – there is even master Yoda on one of the images. In terms of fundamental science, the aim is to obtain (general) chemical resolution within SPM. Atomic resolution is already within STM and AFM. The hope for future applications is to promote the SPM to an analytical method for recognition of single molecules on surfaces. I know one company that is trying to do it in industry. Or to find out, that this way is only a dead end.

Which skills have you developed the most during your research?

What are your main strengths?

I have learned to think a certain way that fits into this kind of science. I hope that I generally have an idea, where I can trust my calculations and my codes, and also where I think that the results are complete bull... My main strength is knowing how to speak to experimentalists – explaining my possibilities and where the quality region of my work has its borders. I also try to understand problems or difficulties they have with their experiments.

What aspects of your research do you enjoy the most?

Except for the coffee... My original motivation was to spread horizons and discover new things (mainly physics) in the world around us. It still is a motivation today, but it is also nice to work



with intelligent people to teach them something useful, to learn from them, and together find solutions to challenging problems.

Has your research progressed as expected, or has it taken some unexpected turns?

As with most research, it is always at least 3x more complicated than you expect. There are many unexpected turns – e.g. I expected to be back in Czech Rep. after 2 years in Finland. I also didn't expect to work from home for 2 years. I expected to be much more advanced with my project (I am generally never happy with the state of my research).

What are your career goals?

I wanted to, and probably still want to, go the full academic path towards being a professor. If successful, I would lead a small group and help those around to find knowledge and skills that will be useful/profitable for them in their future. It would also be nice if this will help Scanning Probe to get the chemical resolution. But there are also days when I just want to be a train conductor.

From the Alumni

Mikael Mohtaschemi

Director of User Analytics, Ekahau

Which area of physics was your research at Aalto?

I did my doctoral dissertation in Computational Physics on the topic of Rheology Modeling.

What is your current job title? What do your roles and responsibilities include? What skills are the most crucial to succeeding in this career?

I recently started a new role as Director of User Analytics at Ekahau, a company specialized in Wi-Fi planning and measurement solutions. I am responsible for advancing the User Analytics operations, through analytics and insights into product usage. The work revolves around data analytics and data engineering. The most crucial skills are the ability to collaborate with a broad variety of Stakeholders as well as technical, scoping, and prioritization skills.

How did your experience at Aalto prepare you for your work after completing your research? Did you have sufficient training in skill development, education, and collaboration/connection with non-academic partners? Which was the most helpful for your work after Aalto?

Aalto provided a good starting point for my further career, for example a broad technical knowledge paired with sound fundamentals as a result of the core education. This is an invaluable asset when absorbing new information. Likewise, the ability to break down complex problems and approach these in a systematic manner while managing scopes and timelines.

How did you find your first position after completing your research at

Aalto?

I was able to utilize contacts I made at Aalto during research collaboration. My supervising Professor Mikko Alava brought up this potential opportunity and it played out well.

What has your career path been since your first position after Aalto? If it does not align with your experience at Aalto, what steps did you take to get on this path?

In 2015 after the pre-examination of my dissertation, I started as Senior Data Analyst at Verto Analytics, a start-up company back then, where I was in charge of one particular data science component and the methodology behind it. I was quickly given team lead responsibility and was thus additionally managing a team of data analysts. The exact responsibilities varied throughout the years, and included client facing roles. Most recently I was in a tech lead position of a hybrid team of data analysts and data engineers. Early this year I jumped on an opportunity to take on a new set of challenges at Ekahau in my current role.

Are there any expectations you had about this career path that have differed from reality, in either a good or bad way?

A positive surprise has been the amount of highly skilled and awesome people from various domains that I have been lucky to work with. Everybody in the data field can tell you that: a) Tools come and go and the evolution is fast, and b) The methodology is often only a small portion in the overall work needed to have solutions running in a production environment.



What would you look for if you were in the position to hire researchers from Aalto?

The exact criteria depend of course on the role, but the ability to collaborate is a great asset. When hiring someone straight out of University you look for potential: a skillset, interest and demonstrated accomplishments in the correct neighbourhood, willingness to dive into the new and the ability of asking your colleagues for help and also helping your colleagues.

Do you have any advice for young researchers studying physics?

Automate your stuff where possible to avoid repeating a long manual thing because of one minor tweak. Also, life moves fast – be present here and now also outside of work.

I graduated from Aalto University with PhD of Theoretical and Computational Physics at May 2014. March 2014 I started to work as Data Analyst and as I worked as Data Analyst at various companies so far after that. During my PhD I studied ultracold Fermi gases, but I was thinking that theoretical physics is far from commercialization. So I knew that if I leave science then I should utilize skills I learned during my PhD, but I should start from scratch in a new industry.

Anna Korolyuk

Data Analyst, Granlund

I love to understand why things went the way they went, so I often reflect about my career and the careers of people I met. In particular, I think about the philosophy of this move from academia to industry that I experienced. I did not leave academia because there was something wrong - I just don't have personality fit for academia, and it wouldn't be fun for me to do icy-cold research and interact with so few people. I remember asking myself: "Do I want to pursue a career in academia?" and "Do I have a competitive advantage to pursue academia?" The answers to both were "No", so I concentrated on moving to industry.

I found my first job at Sanoma, and the jobs that followed, through networking. When I was doing my PhD, I was frequently going to different events, talking to many, many people, which sometimes led to their interest in my skills, and collaboration naturally emerged. Physics students have good technical skills, but they don't deliberately practice networking. When I was learning it, I dedicated one hour per week for going to events and learning to talk to strangers. Perhaps this much time is not needed during job searching, but if you are a PhD student, it's good to meet people from industry for coffee/lunch once every few months to help you learn what work the companies do. A great way is to start from old contacts, such as school classmates and fellow students who went to work in companies. If this is not available (e.g. you are foreigner), "cold calling" through LinkedIn works the same. I would say that my own experience as well as that of other people

shows that networking is a "must" skill both for your first job search and further career. Another helpful thing for me was gaining a realistic understanding of what certain jobs entail in practice – this goes for both academia and industry. For me, this understanding came from meeting many people from both areas. I could then ask myself whether I wanted to do their job, based on reality of what that job is – not on my assumptions of it.

If I would hire researchers, I would look at their mindset. If someone has done a PhD or Masters in Physics, their technical skills are already much higher than average. But there are other important factors, for example teamwork. In industry, all jobs are done in teams; even if someone is incredibly smart, the outcome will be zero if they can't contribute to the team. Luckily, those skills are already taught at Aalto. Finally, there needs to be a desire to make science useful for others. Some people dream of improving the pure knowledge about the world – this is obviously very important in academia. However, industry is all about taking scientific knowledge and commercializing it. If someone doesn't value this aspect, an industry job would feel meaningless and empty. If these things are covered, a person will eventually find a good job in industry. It may take some time in the beginning because you are starting from scratch, but especially in modern Finland there is demand for people who are able to take science and use it for good.

I wish everybody to achieve full self-realization in a professional area, and want to encourage you



to be patient! The transition from science to industry is always starting from scratch and it takes times to start in the new industry (it's the same even if people change companies or different industries). But it's worth doing if you feel that your future is in industry.

Anna also provides career mentoring.

Thomas Carlsson

Patent Attorney, Boco IP Oy Ab

I did my thesis at the laboratory of New Energy Technologies, which I completed in 2006. I developed new methods for assessing and improving the durability of thin-film photovoltaic devices.

I currently work as a patent attorney for a company called Boco IP. We specialize in protecting the intellectual property of our clients. Clients hire us to write patent applications because it takes special expertise to write a valuable application. We also prosecute our clients' patent applications and disputes in various patent offices, especially the Finnish Patent Office (Patenttija Rekisterihallitus, PRH) and the European Patent Office (EPO).

I did not receive any training or take any courses at Aalto which would have related directly to patents, but my scientific papers and doctoral thesis did give me good practice in writing technical texts. After completing my doctoral degree I spent 10 years at the Finnish Patent Office as a patent examiner. They recruited doctors because they had found them particularly suitable for the patent field. In retrospect this seems like a good recruiting strategy, since there are some similarities.

From my first day at the patent office I enjoyed the intellectual challenges that patents present, where technical and legal considerations blend into each other. After reviewing lots of applications I often found myself thinking that "I could write a better application than this...", so eventually I applied to Boco IP where I thought the best applications were being written.

At Boco IP we have a relaxed work atmosphere and equal oppor-

tunities for men and women. There is very little hierarchy and our work teams have a lot of autonomy in deciding how to best serve their present clients and look for new ones. Our daily work is very independent and we have a lot of freedom in setting our own schedules, much like in the world of academic research. Another similarity is that a new patent attorney needs to do quite a lot of studying to learn the legal side of patenting. Lots of good courses are available and the company provides full support for this learning process.

A patent attorney needs good language skills and the ability to think analytically and present matters clearly in written form (and sometimes orally). It's good to be well-organized and to enjoy the challenge of finding winning arguments. Most patent attorneys do not (and cannot) specialize in a narrow technical field. Instead, we serve many clients whose inventions can be very different from each other. The legal aspect of patenting and the experience we gain from processing lots of applications is our core knowledge. We consult the client's experts to learn the technical details we need to write a good application or to build a good argument.

The patent attorney business tends to move in a steady turtle trudge, not in rabbit leaps. The demand for our services typically remains quite steady even when the economy sinks, but then it does not increase very much in a boom, either. Since the path to becoming a qualified patent attorney extends over 3-4 years, every new hire is made for the long term. The de-



mand for people who know physics is likely to grow in the patenting field as many traditional industrial companies expand their research activities into high-tech fields such as sensor applications for the internet-of-things. Our company has hired people who have recently completed or are just about to complete their degrees (Bachelor, Master or Doctor) at Aalto. I am presently tutoring one of them.

In addition to the patent attorney profession, a career in the field of patents can start at the Finnish or European Patent Offices which recruit new workers regularly. You can also work as a patent engineer at a company where you manage their patent portfolio and make decisions on which ideas should be patented and which should remain trade secrets. I would recommend this field especially to students who think that they might enjoy working with slightly more abstract problems (having to do with language and legal interpretation) than what practical research can offer.

DEPARTMENT of APPLIED PHYSICS



Aalto University

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**Interested in contributing to our next issue?
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