LUND UNIVERSITY

NanoLund

ANNUAL REPORT | 2022

2022 in brief

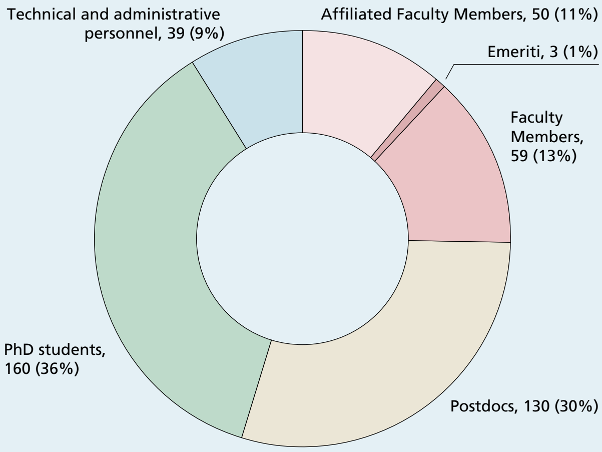
RESEARCH AREAS

Materials & Manufacturing	Quantum Physics	Semiconductor Technology
Photons	Life Science & Nano	Nanosafety

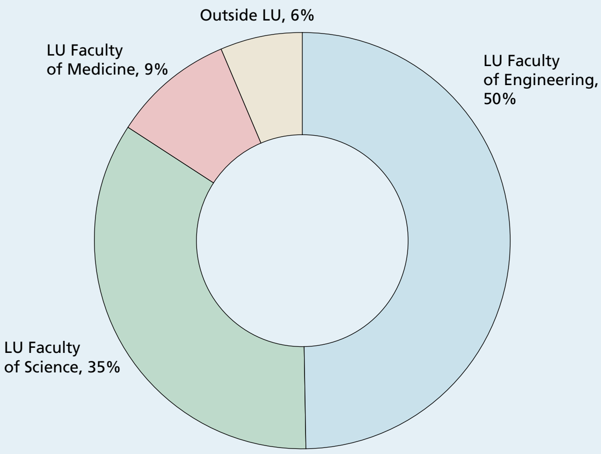
KEY RESOURCE AREAS

Lund Nano Lab	Lund Nano Characterization Labs	Education & Outreach

NANOLUND PER PERSONNEL CATEGORY



FACULTY AFFILIATION



CURRENT NUMBERS

441 number of people engaged in NanoLund

239 MSEK funding

66% from external funding sources

7.25 average impact factor

32 contributing LU divisions

33% of staff are women

59 Faculty Members

50 Affiliated Faculty Members

160 PhD-students

120 undergraduate student members

NANOLUND INCLUDES

14 recipients of European Research Council (ERC) awards

4 Wallenberg Scholars

3 Swedish Research Council Distinguished professors

18 ongoing EU-projects

5 ongoing Wallenberg projects and VR Research environment grants

With human curiosity, we contribute to sustainability


Photo: Johan Persson

During 2022 it has been inspiring to visit and engage with a broad range of large and small companies that makes products and technologies used across our society. Sustainability has really come into focus for industry and there is a true drive to address the huge challenges facing us to recycle much better, use less energy and make products that improve the daily lives of the many. NanoLund's science, technology and competencies can contribute in many important ways to make this happen. An environment such as ours, spanning all the way from deep fundamental research to applications in society is clearly understood to be needed to have this impact. Openness across disciplines and mindsets is not easy to achieve, but we can be proud to have come a long way in this regard.

We implemented our new research area structure in 2022 and continued to develop our infrastructures with major new investments. Having a unique assembly of excellent infrastructures for characterization and fabrication combined with excellent theoretical understanding and inventive and engaged students, all in one place, is an incredible luxury. In our everyday work, we should remember to sometimes lift our gaze and look around – not many other places worldwide give such opportunities. We will in the coming year work for us all to meet and engage to explore all of this even more. We can look forward to the development of Science Village where an assembly of amazing infrastructures, including our new Nanolab, will emerge together with new meeting places for all of us. Every new connection and every new idea will add to our understanding of the world and may help to make it a better place.

Finally, a warm thanks to all our staff, students, and partners, inside and outside the University, for your ongoing support, understanding and contributions. It is all of us working together that makes NanoLund a great place to do research, educate and make a difference in society.

Anders Mikkelsen | Director NanoLund

This is NanoLund

NanoLund is the center for research, education and innovation within nanoscience and nanotechnology at Lund University, founded in 1988. It is a strategic research area funded by the Swedish Government.

NanoLund encompasses research groups in the faculties of engineering, science and medicine at Lund University as well as collaborators outside the University. It is Sweden's largest research environment in its field. The research topics range from materials science and quantum physics to applications in energy, electronics, photonics, personalized medicine and nanosafety.

Our research is organized into sub-areas to realize NanoLund's vision to be a world-leading research center that uses the unique opportunities offered by nanoscience to advance fundamental science and to address societal challenges.

OUR RESEARCH:

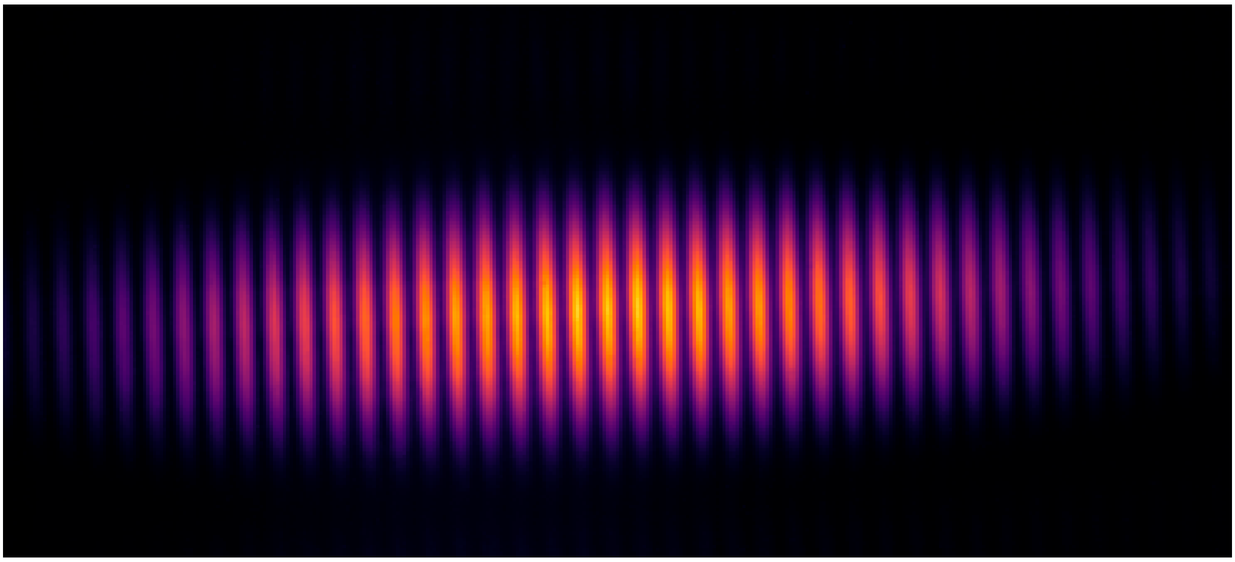
MATERIAL SCIENCE AND MANUFACTURING provide the physical basis for much of our fundamental research as well as technologies for future industrial production. We aim to relate the atomic structure to the properties of a material and understand when and how nanostructures form and what structure to expect. Even very small changes in formation conditions can cause dramatic changes in the resulting nanostructure, and a challenge is to detect and control these. Our key expertise is in solid-phase nanostructures fabricated from the vapor phase, especially compound semiconductors and metal low dimensional structures. To ensure the development of high-quality nanostructures, experiments is combined with theory and simulations to warrant a fundamental understanding of the material formation process. We use advanced, often in-situ, techniques to characterize the nanostructures and continuously develop new processes and applications.

SEMICONDUCTOR TECHNOLOGY is vital for future communication systems, energy efficiency within both electronics and electrification, and for improving renewable energy sources and autonomous systems. We strive to find new ways of designing and implementing high-performance electronics on the nanoscale. Smaller device geometries lead to higher operation frequencies, larger small-signal gain, and better packing density. Wide bandgap semiconductors show a strong promise for the power converters that are critical in the electrification of society. Nanoscale field-effect transistors with narrow bandgap materials can realize and explore the high-frequency performance towards THz. Optoelectronic devices are developed for high-performance solar cells, light-emitting diodes and photodetectors. Device design is explored in the atomistic limits to push performance to extreme levels, and we work towards functional integration on Si and Si CMOS.

QUANTUM PHYSICS is where we develop the theoretical tools to better describe quantum phenomena, work to experimentally observe them, and then identify advanced device concepts where quantum effects enable better performance. In nanostructured systems, pronounced quantum behavior gives rise to exciting new fundamental physics as well as potential applications.

The superposition of states and entanglement open completely new perspectives for sensing and communication technology. We explore novel quantum states in many- and few-body systems, photons interacting with quantum systems, and superconductor-semiconductor hybrid structures. Quantum thermodynamics develops new paradigms for energy conversion and quantum devices at the nanoscale, where thermal and quantum fluctuations may conspire to profoundly alter the physical properties and lead to fundamentally new physics.

PHOTONS concerns light-matter interactions in nanoscale materials and includes experimental and theoretical research where electromagnetic radiation from microwaves to X-rays is used as a probe, generated or absorbed by the material. We employ a broad range of methods, from basic spectroscopic techniques to combinations of time- and spatially-resolved probes, and different phenomena are harnessed, such as absorption, photoluminescence, electroluminescence and scattering. We study light-triggered exciton and charge carrier dynamics in a variety of nanostructures, use X-rays for locally probing the structural or electronic properties of semiconductors



X-ray image from the NanoMax beamline at MAX IV Laboratory, showing the interference pattern from a Young's double slit experiment. The X-ray beam illuminates two slits etched into silicon, and the visibility of the fringes is used to measure the coherence. The high-quality X-ray beam at MAX IV makes this facility uniquely suited for nanoscience, imaging and crystallography. Image: Hanna Dierks, Jesper Wallentin, Ulrich Voigt

and catalytic centers, investigate photophysical properties of individual nanostructures, and model interactions between light and nanostructured semiconductors, as well as interactions in complex materials.

LIFE SCIENCE AND NANO utilize our capabilities to create structures on the relevant length scales for cells and molecules for fundamental studies in novel areas and for biomedical applications in areas where there are urgent needs for better functioning tools within research and health care. We strive for a detailed understanding of the interactions between cells and nanostructures concerning cell behavior, physiology and mechanics. This knowledge will allow us to develop novel nanoscale tools with applications in biology and medicine. For example, nanoscale devices that can interact with cells with minimal perturbation or single-molecule sensitivity; injection, nanobiopsy, mechanosensing, or nanostructured tools that can control the cell behavior with respect to differentiation, migration, proliferation and stimulation. We work for translation of results into applications in biophysics, brain science, diagnostics and personalized therapy.

NANOSAFETY explores the fundamental connections between nanostructure properties and human and environmental toxicology, as well as emissions and exposure in all stages of the lifecycle of a nanomaterial, helping to provide the tools needed for safer design development and production of novel materials.

Emissions and exposures are studied with state-of-the-art instruments both in workplace environments and in controlled laboratory settings. The toxicological effects are studied on all levels: single cells, organisms, and ecosystems using various in-vitro, ex-vivo, and in-vivo methods. Safe production and use of nanomaterials require knowledge of nano-related toxicity as well as effective risk management ranging from legislative and regulative levels down to hands-on work processes.

SOCIETAL CHALLENGES WE AIM TO ADDRESS:

- **Enabling a sustainable society.** Paradigms and technologies for efficient harvesting and use of energy, and for nanomaterial-based products that are sustainable and safe from a life-cycle perspective.
- **A pathway to the future information society.** New physical concepts, smart materials, nanoscale devices, sensors and their heterogeneous integration to enable next-generation information technology.
- **Precision medicine.** Nano- and microstructures for biomedical research at the single-cell level and for fast point-of-care diagnostics, enabling targeted, individualized therapy.
- **Interaction with business and society.** Collaboration with the private and public sectors both locally and internationally. Jointly we can address sustainable development goals, help solve societal challenges, and create new industry.

Looking back at highlights of the year

LUND UNIVERSITY IS PARTNERING WITH CENTRE FOR III-NITRIDE TECHNOLOGY – C3NIT

III-nitride semiconductors have proven to be extremely suitable for high-frequency electronics as well as for power electronics. C3NiT is a competence center funded in equal parts by Vinnova and partners from industry and academia. Lund University is now joining Linköping University and Chalmers as an academic partner for the coming five years. The center will be hosted in Lund under the leadership of Professor Vanya Darakchieva.

FIRST NANOLUND MENTOR PROGRAM EVENT HELD

As a gateway into the NanoLund Mentoring program, a career development workshop for PhD students was held with the aim to teach transferable skills that non-academic employers value from people with an academic background – and how to use them to make an attractive CV or stand out in an interview situation. This workshop was the first event in the NanoLund Mentoring program, which kicked off in January 2023.

MASTER EQUATION TO BOOST QUANTUM TECHNOLOGIES

Many everyday technologies make use of feedback control routinely in order to manage the operations of devices and processes. But physicists do not yet have an equivalent understanding of feedback control at the quantum level. NanoLund researchers Björn Annby-Andersson and Peter Samuelsson have developed a "master equation" – the "Quantum Fokker-Planck equation", that enables physicists to track the evolution of any quantum system with a feedback control over time and helps engineers understand feedback at the quantum scale.

Annby-Andersson, B. et al.
Phys. Rev. Lett. 129, 050401
10.1103/PhysRevLett.129.050401.
https://doi.org/10.1103/PhysRevLett.129.050401

Photo: Jessika Sellergren

WORKING TOWARDS A SEMICONDUCTOR STRATEGY FOR SWEDEN

In order to strengthen Swedish competitiveness, Lund University is taking the initiative to mobilize national expertise in the semiconductor field to suggest a strategy for semiconductor technology in Sweden. A proposal was discussed in a meeting in Stockholm hosted by Lund University and the work continues.

"Through a nationally shared agenda, Lund has the opportunity to contribute with its collective expertise in semiconductor technology," says Lars-Erik Wernersson, Professor of Nanoelectronics at LTH and one of the people driving the national collaboration.

BIG INVESTMENT IN MATERIALS SCIENCE WITH WISE

The Wallenberg Initiative Materials Science for Sustainability (WISE) is the largest-ever investment in materials science in Sweden, encompassing major efforts at seven of Sweden's foremost universities. Among the submitted 193 applications in the first PhD and postdoc project call, 90 projects have been granted funding, awarded in total of 260 million Swedish Crowns by the Knut and Alice Wallenberg Foundation (KAW) for a period of up to four years. Awarded projects are distributed broadly across seven universities.

"This is of great importance to us at NanoLund, since materials science enables us to work with several aspects of such a prioritized topic as sustainability, says Maria Messing, Deputy Director of NanoLund and one of the PI:s that were granted funding.

NanoLundians Anders Mikkelsen, Heiner Linke, Karen Edler, Kenneth Wärnmark, Kimberly Dick Thelander, Magnus Borgström, Mattias Borg and Tönu Pullerits are also granted funding in this initial round.

"LIGHT AND MATERIALS" ONE OF FIVE LUND UNIVERSITY PROFILE AREA

One of the Lund University profile areas appointed for the period 2022–2030 is "Light and Materials – from fundamental understanding to industrial and societal needs". The profile will benefit from the very recent exciting advances in our capability of measuring and controlling light and materials.

By significantly improving our understanding of the natural world, we create technologies that enable a sustainable and healthy society. Lund University has a unique opportunity to conduct research in this area thanks to the collective expertise and facilities that will be gathered in and around Science Village.

DIESEL WORSE THAN NOISE ACCORDING TO THE HEART

Photo: Evelina Lindén

What impact do diesel exhaust particles and traffic noise, alone and combined, have on intermediary outcomes related to the autonomic nervous system and increased cardiovascular risk?

When 18 healthy adults were exposed to four scenarios in a randomized cross-over study, researchers found that the heart-rate variability (HRV) decreased during exposure to diesel exhaust, both alone and combined with noise, but not during noise exposure only. These differences were more pronounced in women.

Each exposure scenario consisted of either filtered, clean air or diesel engine exhaust (particle mass concentrations around 300 µg/m3), and either low (46 dB(A)) or high (75 dB(A)) levels of traffic noise for three hours. This indicates activation of irritant receptor-mediated autonomic reflexes, a possible mechanism for the cardiovascular risks of diesel exposure.

Stockfelt, L. et al

Inhalation Toxicology, 34:5-6, 159-170

https://doi.org/10.1080/08958378.2022.2065388

RESEARCHERS TAKE FIRST STEP TOWARDS CONTROLLING PHOTOSYNTHESIS USING MIRRORS

With the help of mirrors, placed only a few hundred nanometers apart, a research team led by NanoLundian Tönu Pullerits has managed to use light more efficiently. The finding could eventually be useful for controlling solar energy conversion during photosynthesis, or other reactions driven by light. One application could for example be converting carbon dioxide into fuel.

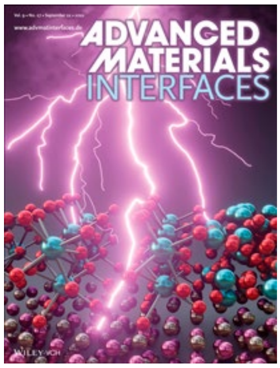
Wu, F. et al

Nat Commun 13, 6864 (2022)

https://doi.org/10.1038/s41467-022-34613-x

STUDYING FERROELECTRIC BEHAVIOR

Researchers at NanoLund have evaluated an alternative method to realize Ferroelectric Hafnium-Zirconium-Oxide (HZO) on the high-mobility semiconductor InAs, using a flash lamp annealer (FLA), where annealing takes place in the millisecond regime as compared to tens of seconds using traditional rapid thermal processing (RTP). Ferroelectric HZO is typically achieved by crystallization of an amorphous thin film via rapid thermal processing RTP at time scales of seconds to minutes.



Athle, R. et al

Adv. Mater. Interfaces 27/2022

https://doi.org/10.1002/admi.202201038

"NANOSCIENCE AND SEMICONDUCTOR TECHNOLOGY" BECOMES LTH PROFILE AREA

LTH (the Faculty of Engineering at Lund University) launches profile areas to be able to stronger respond to societal challenges. They are intended to be horizontal platforms for research, collaboration, and education and a way to develop research and make it visible and concrete. "Nanoscience and Semiconductor Technology" is among the seven profile areas. "I am very happy that Nanoscience and Semiconductor Technology will become one of the first LTH profile areas", says Anders Mikkelsen.

NanoLund is represented in all but one of LTH profile areas.

NANOSCIENTIFIC ALUMNI EVENT

In October the Technical Nanoscience program with the support of NanoLund arranged an alumni event for its students. The alumni had chosen different careers and career paths and openly shared their experiences with the crowd of curious students.

THE FIRST THREE NANOLUND DISTINCTION PRIZE AWARDEES DESIGNATED

The NanoLund Distinction is awarded to PhD students within the NanoLund environment who have shown particular dedication to research, education and outreach activities, have acquired broad knowledge within nanoscience research and its societal relevance and impact, and have demonstrated research independence and leadership.

The first three NanoLund Distinction receivers are Yen-Po Liu, Lukas Hrachowina, and Sven Dorsch. They have actively and successfully contributed to the mission of NanoLund in public outreach, have taken leadership roles, made significant technical developments that can be used by a broad group of fellow scientists and students, and demonstrated innovative, independent, cross-disciplinary research.

NEW SUPERCONDUCTOR BY USING QUANTUM INTERFERENCE

A diode is one of our most well-known and useful semiconductor components. It has the characteristic property of conducting electricity much better in one direction than in the other. Researchers at NanoLund and at the University of Copenhagen have now proposed a new way to make a superconducting diode. In a superconductor, a so-called supercurrent can flow without dissipating energy or generating heat, and a superconducting diode supports a larger supercurrent in one direction than in the other. The new proposal is based on using quantum interference in a geometry where a supercurrent can flow along two different paths, one of which contains a tunnel junction in a semiconductor nanowire or quantum point contact. The main advantage of the proposal is the large achievable supercurrent asymmetry and that the diode can be controlled electrically. This might enable applications in protected superconducting qubits and other quantum technologies.

Seoane Souto, R. et al
Physical Review Letters 129, 267702
https://doi.org/10.1103/PhysRevLett.129.267702

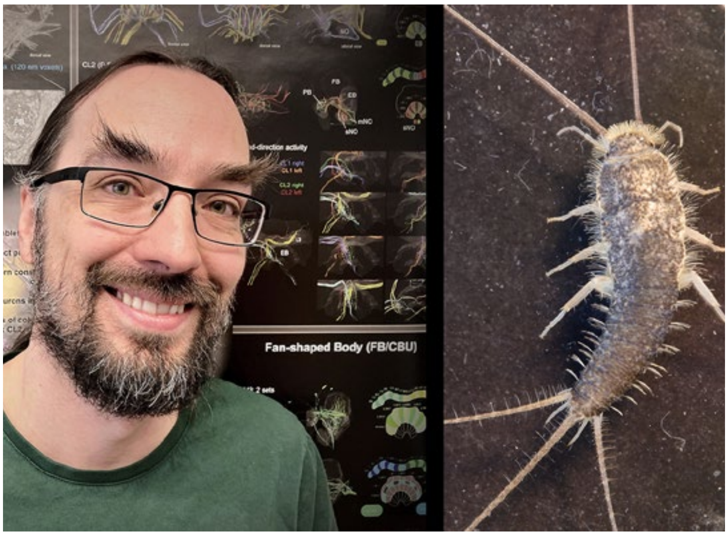


Photo: Johan Joelsson and Rene Sylvestersen, Wikimedia Commons

ERC CONSOLIDATOR GRANT TO INSECT BRAIN MAPPING

NanoLundian Stanley Heinze gets an ERC Consolidator Grant from the European Research Council, for creating a deeper understanding of the insect brain.

In total, Stanley Heinze, along with two PhD students and two postdocs, will map the brains of 18 insect species including silverfish, bees, grasshoppers, and butterflies. By first examining the entire brains of around 100 insect species, it will then be possible to go in and study the behavioral part of the 18 selected species.

"With a deeper understanding of insect decision-making, we can eventually understand how this might be applicable to humans. Whether you want to go to an anthill or a shopping mall, decisions are driven by cells in our extremely complex brains," says Stanley Heinze.

NEW TYPE OF SOLAR CELL IS BEING TESTED IN SPACE

NanoLundians Magnus Borgström and Lukas Hrachowina and their group of nanoengineering researchers made a breakthrough, succeeding in building photovoltaic nanowires with three different band gaps. This means that one and the same nanowire consists of three different materials that react to different parts of solar light, making a better match for the solar spectrum compared with today's silicon solar cells. As the nanowires are light and require little material per unit of area, they are now to be installed for tests on satellites, which are powered by solar cells and where efficiency, in combination with low weight, is the most important factor.

"The big challenge was to get the current to transfer between the materials. It took more than ten years, but it worked in the end," says NanoLund principal investigator Magnus Borgström, professor of solid state physics, who wrote the articles with Lukas Hrachowina, Yang Chen, Enrique Barrigón, and Reine Wallenberg.

Hrachowina, L. et al
Materials Today Energy, Vol 27, 2022
https://doi.org/10.1016/j.mtener.2022.101050
Hrachowina, L. et al
Nano Research vol 15 (2022)
https://doi.org/10.1007/s12274-022-4469-1

JOINT FORCES TO RENEW POWER ELECTRONICS

In a project together with Linköping University and Chalmers University of Technology, researchers at NanoLund have proposed the hot-wall metalorganic chemical vapor deposition (MOCVD) as a prospective growth method to be further explored for the fabrication of β-Ga_2O_3 – the most stable polymorph of Gallium trioxide. The newly developed hot-wall MOCVD gallium oxide reactor concept offers a versatile method with the potential for cost-effective industrially viable epitaxial growth.

Among the financers are the Swedish Energy Agency, the Swedish Governmental Agency for Innovation Systems (VINNOVA), the Swedish Research Council, the Swedish Foundation for Strategic Research, the National Science Foundation (NSF) and the KAW Foundation together with Ericsson, Epiluvac, Hexagem, Hitachi Energy, Saab, and the Air Force Office of Scientific Research.

Gogova, D. et al

AIP Advances 12, 055022 (2022)

https://doi.org/10.1063/5.0087571

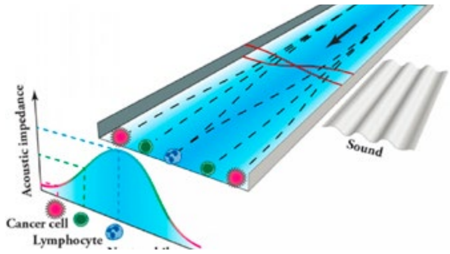
LARS SAMUELSON RECEIVES THE IVA'S GREAT GOLD MEDAL

Lars Samuelson, professor of nanotechnology and semiconductor electronics at LTH and founder of NanoLund, is awarded the Royal Swedish Academy of Engineering Sciences (IVA) Great Gold Medal for significant contributions to the Academy's field of activity. The award is presented by IVA's patron, HM The King.

"I am incredibly pleased and honored to be considered for the unique award of the IVA Great Gold Medal. I see this as a collective award to the amazing environment of talented students and researchers that I have had the privilege to lead and work with," says Lars Samuelson.

He is awarded the prize for his internationally outstanding contributions as an innovative researcher and research leader in nanoscience and nanotechnology, and for the application of scientific results, not least in semiconductor technology.

Photo: Kungl. Ingenjörsvetenskapsakademien (IVA)



Per Augustsson

ERC GRANT FOR RESEARCH ON SEPARATING CELLS USING ULTRASOUND

NanoLundian Per Augustsson, Associate Professor at the department of Biomedical Engineering at Lund University, has been awarded a European Research Council Proof of Concept Grant for his work on how liquids and cells behave in a sound field.

"In order to understand the role of different types of blood cells in healthy and sick individuals, it is of interest to medical researchers to be able to separate different types of cells from the blood so they can be studied in detail. We believe that ultrasound-based separation can give them a powerful tool to achieve this", says Per Augustsson.

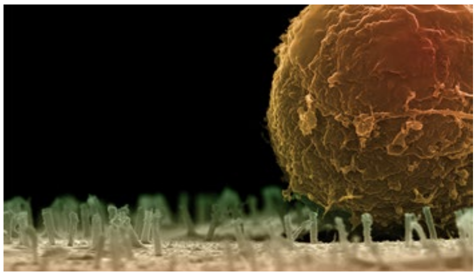


Photo: Martin Hjort

ERC PROOF OF CONCEPT FOR BLOOD STEM CELL NANOTUBES

Martin Hjort, researcher at NanoLund, has together with Jonas Larsson and Ludwig Schmiderer developed the method of using nanotechnology to propagate blood stem cells for stem cell transplantation.

"We have built a carpet of microscopic nanotubes. When the blood stem cell lands on the mat, the tubes form a channel through the cell surface, where the molecules we want to add to the cell can enter", explains Martin Hjort.

The project has now been awarded a Proof of Concept grant from the European Research Council, ERC. The grant of €150 000 is part of the EU's research and innovation program, Horizon Europe.

STEPHANIE REIMANN NEW MEMBER OF ROYAL SWEDISH ACADEMY OF SCIENCES

Photo: Åsa Wallin, Knut and Alice Wallenberg Foundation

Professor in Mathematical Physics at Lund University, Stephanie Reimann, was elected new member of the Class for Physics of the Royal Swedish Academy of Sciences (Kungl.Vetenskapsakademien, KVA), at the Academy's General meeting in May.

KIMBERLY DICK THELANDER NEW FELLOW OF THE ROYAL ACADEMY OF ENGINEERING SCIENCES

Photo: Magnus Bergström, Knut and Alice Wallenberg Foundation

Together with other prominent researchers and experts in the private and public sectors, Kimberly Dick Thelander, Professor of Materials Science has been inducted into the Chemical Engineering division of the Royal Swedish Academy of Engineering Sciences (IVA). The academy promotes "engineering and economic sciences and the advancement of business and industry for the benefit of society." It is the world's oldest engineering academy, founded in 1919, and has 1 300 inducted inducted Swedish and foreign Fellows.

OFENTSE MAKGAE AMONG THE DELEGATES TO LINDAU NOBEL LAUREATE MEETINGS

The Lindau Nobel Laureate meetings are annually hosting an event on the island of Lindau in south Germany, where about 30–40 Nobel Laureates convene to meet the next generation of leading scientists – students, PhD students and post-docs. 2022, NanoLundian postdoctoral research fellow Ofentse Makgae was one of the 15 Swedish delegates participating.

TAILORING METAL-SEMICONDUCTORS

Earth-abundant transition metal phosphides (specifically copper(I) phosphide) are promising materials for energy-related applications. Synthesizing well-defined metal–semiconductor nanoparticle heterostructures to enhance the photocatalytic performance can be done by efficiently separating the charge carriers. This must be done in a controlled manner and by characterizing their structural and morphological properties in detail. In this study, the interface dynamics occurring around the synthesis of Ag–Cu_3P nanoparticle heterostructures is investigated by a chemical reaction between Ag–Cu nanoparticle heterostructures and phosphine in an environmental transmission electron microscope.

The results will help better understand dynamic processes and enable facet-engineered surface and heterointerface design to tailor the physical properties. They also highlight the potential to select specific interfaces in metal–semiconductor heterostructures using templates and varying process parameters. This will help evaluate the impact of their tailored structural and morphological properties on their photocatalytic performance in future experiments.

Seifner, M. S. et al
J. Am. Chem. Soc. 2022, 144, 1, 248–258
https://doi.org/10.1021/jacs.1c09179

DILIGENT PARTICIPATION IN "CULTURE NIGHT"

Able to celebrate the annual "Culture Night" on site in Lund again, NanoLund and the Department of Physics contributed by showing the amazing world of physics – covering topics from the smallest elements to the deepest mysteries of the universe.

Visitors could dive into the exciting world of Physics and see how nature is studied, its fundamental laws, and their applications – from the smallest building blocks of matter to the mysteries of the cosmos. There were presentations, talks, and walks around the labs, and the public was invited to join in for fun experiments and demonstrations, as well as a quiz for the youngest visitors.

"To me, participating in Kulturnatten is something that we should eagerly continue with, because it's a wonderful chance to open our doors to the community, share what we are so passionate about and get to see that same excitement and passion in our visitors – young and old alike," says Adam Burke, outreach coordinator at NanoLund.

DISCOVERING THE DYNAMICS OF LIPID NANOPARTICLES

For the first time researchers have studied the dynamics of highly swollen lipid sponge phase nanoparticles (L_3NPs) and how they are affected by the encapsulation of two enzymes of different size using the non-invasive scattering method neutron spin echo (NSE) spectroscopy. Complementary atomistic molecular dynamics (MD) simulations of the inner parts of the L_3NPs were performed for the empty L_3NPs and L_3NPs containing aspartic protease. Lipid membranes are highly mobile systems with hierarchical, time and length scale dependent, collective motions including thickness fluctuations, undulations, and topological membrane changes, which play an important role in membrane interactions. The aim was to reveal the effect of the encapsulated proteins on the nature of the dynamic properties of the lipid membranes in water, focusing on membrane bending rigidity.

Gilbert, J. et a

Nanoscale 2022

https://doi.org/10.1039/D2NR00882C

GETTING A SNEAK PEEK INTO SCIENCE

"It's a rare opportunity to be inside the labs, seeing new innovative ideas. It was great fun to be part of creating gold nanoparticles, for example. I also found it really interesting to look in the microscope, and see what things look like. In school we study maths and theory – here, you get to see how it all can be used practically. See theory in context," says Jennifer Cately from S:t Petri School in Malmö.

Together with Joanna Persson and Alexander Lundh, who also just finished second grade in high school, she spent two weeks at NanoLund as part of a program aiming to rise the priority of scientific perspectives – Forskningsnätet Skåne, Researcher's net, Skåne. All three of them happily refrained from the first couple of well-deserved summer vacations.

"Seeing how things work and learning about important research that is going on is really fascinating. These are things you don't get to see otherwise. Conducting experiments, not knowing what the results will be! Yesterday we got to do microfluidics. That includes biology, how to separate bacteria – medicine and how it can be linked to physics and nanotechnology," says Joanna Persson.

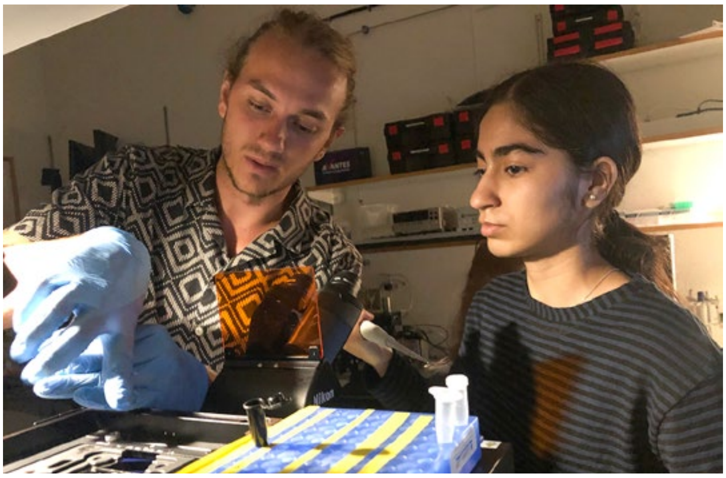


Photo: Evelina Lindén

ANNE L'HUILLIER RECEIVES THE WOLF PRIZE

Photo: Kennet Ruona

Anne L'Huillier wins the prestigous Wolf Prize in Physics for pioneering contributions to ultrafast laser science and attosecond physics. She was also awarded the Gothenburg Lise Meitner Award for being at the forefront of ultrafast laser science since its inception, with her pioneering contributions to high-order harmonic light generation, which is a base technology for attosecond science. Her research has helped foster the field of attosecond science, allowing scientists to visualize the movements of electrons in light-induced processes, which can be used to understand chemical reactions on the atomic level.

DETECTING NEW CATALYSTS

Nickel (Ni)-promoted Molybdenum (Mo)-based catalysts are used for hydrotreatment processes in the chemical industry where the catalysts are exposed to high-pressure hydrogen (H_2) at elevated temperature. In this environment, the catalyst transforms into the active phase, which involves the reduction of the oxide. This is the first in situ study on the reduction of alumina supported Ni- and Mo-based catalysts in 1 mbar H_2 using ambient-pressure X-ray photoelectron spectroscopy (APXPS). The study confirms that mixing Ni and Mo lowers the reduction temperature of both Ni- and Mo-oxide as compared to the monometallic catalysts and shows that the MoO_3 reduction starts at a lower temperature than the reduction of NiO in NiMo/Al_2O_3 catalysts. Additionally, the reduction of Ni and Mo foil was directly compared to the reduction of the Al_2O_3-supported catalysts and it was observed that the reduction of the supported catalysts is more gradual than the reduction of the foils, indicating a strong interaction between the Ni/Mo and the alumina support.

Gericke, S. M. et al

Catalysts 2022, 12, 755.

https://doi.org/10.3390/catal12070755

NEW COLLABORATION MODELS DEVELOPED FOR A SUSTAINABLE PRODUCTION INDUSTRY

Many companies within the Swedish production industry are world-leading and strongly committed to developing competitive manufacturing processes and products that can pave the way towards a more sustainable future. To succeed they often need to understand their materials on the nanoscale. But although Sweden has access to excellent material characterisation facilities such as MAX IV and ESS it is not straightforward for industry to use them.

NanoLund researchers in sustainable production, materials engineering and synchrotron light radiation have taken steps together with industry to develop new long-term collaboration methods starting from the industrial challenge. Filip Lenrick, project manager and researcher in the Sustainable Production Initiative and NanoLund says: "It is very inspiring to collaborate in this way. When companies are involved in the whole process, from application to design and implementation of an experiment and in the data analysis, it leads to great synergy effects. To bring everyone together and engage us all in the value chain with actors from academic research, material production, and representatives from the manufacturing of equipment and process development – it is unique!"

The collaborations have resulted in a number of experiments using x-rays and neutrons and the results are being published and used in product development.

Zhu, L. et al

Surface and Interface Analysis, Vol. 54, Issue 2

https://doi.org/10.1002/sia.7024Spin-offs

SPIN-OFFS ATTRACTS NEW INVESTMENTS

NanoLund spin-off companies continues to attract investments for innovation development. Good news during the year comes from Aligned Bio and AcouSort that both were awarded around €2.5 million in funding from the European Innovation Council. NeuroNano AB recently issued new shares to take the development of biocompatible electrodes closer to the clinical phase. We are also pleased to note Alixlabs and NordAmps made it to NyTekniks 33-list of Sweden's most promising young start-ups in tech.

Photo: Oskar Ström

BIGGEST STUDENT RETREAT SO FAR

"Industry versus Academia" was the theme for this year's NanoLund student retreat. It took place in Höllviken with more than 85 participants attending the exciting program – the biggest NanoLund student retreat so far!

In addition, a very apprechiated postdoc-arranged workshop gathered many of the early researcher's to share and discuss experiences from the usually far from straight road to travel as a junior scientist.

CARBON NEUTRAL DIGITALISATION

The Bio4Comp project demonstrated that network-based biocomputation (NBC) is a viable approach to complex computational problem solving, offering significant lower energy consumption than electronic processors. The project presented a computation platform that uses orders of magnitude less energy than electronic computing as a possible contribution towards a carbon neutral digital industry.

The project resulted in a roadmap, which identifies key scientific and technological benchmarks for upscaling of NBC. Possible solutions include methods for the large-scale production of nanoscale physical networks, as well as the integration of large numbers of biomolecular motors with methods of biological information storage. Bio4Comp was funded by the European Commission (Grant No 732482) and was coordinated by Heiner Linke from 2017-2022.

Konopik, M. et al

Nat Commun 14, 447 (2023)

https://doi.org/10.1038/s41467-023-36020-2

van Delft, F. et al

Nano Futures, Vol 6, Nbr 3

10.1088/2399-1984/ac7d81

NANOLUND WELCOMES FOUR INDUSTRIAL PHD STUDENTS

Researchers within NanoLund continue the work to strengthen collaborations between academia and industry. One example of long-term collaboration is the education and training of doctoral students within needs-driven research areas. The Strategic Science Foundation (SSF) has granted funding for three new industrial PhD students from the companies Ericsson, IR Nova and SECO Tools. One additional PhD student from Volvo Cars has started within the C3NiT Competence centre supported by Vinnova.

Collaboration and innovation

Our vision is to apply cutting-edge nanotechnology to address societal needs. To reach that goal NanoLund works to support collaboration and innovation. By engaging together with companies and societal actors, we can contribute to new solutions. This means that we aim for collaborations within innovation and development areas where our stakeholders face common challenges and where research and knowledge within NanoLund can be part of a solution.

We strive to develop long-term collaborations with stakeholders in industry, institutes, and society. In 2022 we see a large increase in the co-publication of scientific results with industrial partners and four industrial PhDs started their doctoral education with NanoLund. Altogether this indicates that long-term partnerships bear fruit.

Researchers within NanoLund are encouraged to validate how research results can be utilized for new concepts and ideas of relevance to society and industry. We aim to support innovation activities in different ways and are very proud of all the companies spun out of NanoLund – as many as 30 companies since the start of the research center in 1988.

Table 1. Spin-off companies from NanoLund

Spin-off companies from NanoLund (companies in operation by December 2022, in alphabetical order). The number of employees has been deducted from the latest available public yearly report (2021).

COMPANY		STARTING YEAR	NUMBER OF EMPLOYEES 2021
Acconeer	Develops radar solutions based on pulsed coherent radar technology combining extremely low energy consumption with high accuracy.	2011	41
AcouSort	Combines acoustics and microfluidics to separate and sort cells and particles in biological and clinical samples.	2010	14
Aligned Bio (previously AlignND Systems)	Utilizes the light-guiding properties of semiconductor nanowires to develop a biosensor platform for analyzing biomarkers such as proteins and other molecules.	2019	5
AlixLabs	Provides a method to manufacture nanostructures with a characteristic size below 20 nm for the electronics industry.	2019	2
BrainLit	Combines light-emitting diode (LED) technology with knowledge about the effects of light on human anatomy and physiology for new in-door lighting.	2012	18
Deep Light Vision	Develops a non-invasive method (Ultrasound Optical Tomography) using laser light for clinical diagnosis of for instance cancer or vascular disease.	2021	No available data
NordAmps (previously C2Amps)	Develops a new technology for transistors by combining the high performance of semiconductor materials (In(Ga)As-nanowires) with the economy of scale supported by silicon substrates.	2016	3
Cellevate	Provides the biotech industry with cell culture systems where cells are grown in a porous network of nanofibers mimicking different types of body tissues.	2014	5
Glo (aquired by Nanosys 2021)	Developed micro-LEDs in the colours red, green and blue using III-nitride-based nanowires.	2003	No available data
Hexagem	Develops wafers of the semiconducting material gallium-nitride using a new patented technology that completely avoids threading dislocations resulting in a material of higher quality.	2015	5
NeuroNano	Develops innovative electrodes for deep brain stimulation (DBS) with the aim to improve the quality of life for people with various neurological illnesses.	2006	6
Obducat	Develops and supplies lithography solutions for production and replication of advanced micro and nanostructures for industrial needs.	1989	40
Spermosens	Develops a diagnostic technology for male infertility aiming to predict the outcome of in-vitro fertilizations.	2019	4
Watersprint	Develops and manufactures products for water purification using light-emitting diodes (LED) in the ultraviolet spectrum C (wavelengths ranging from 100 to 280 nm).	2013	7
Wren Therapeutics Ltd.	Aims to discover and develop drugs for protein-misfolding diseases such as Alzheimer's and Parkinson's disease. The work is based on research on the chemical kinetics of the misfolding process.	2016	No available data

Cutting-edge infrastructure – open research facilities, world-class clean rooms and state-of-the-art equipment

The scientific work done at NanoLund is enabled and complemented by our infrastructures: Lund Nano Lab – the nanofabrication facility; and Lund Nano Characterization Labs – a distributed network of many characterization laboratories at Lund University.

LUND NANO LAB – MYFAB LUND

Lund Nano Lab (LNL) is a key resource for nanoscience and nanotechnology at NanoLund. The clean room facility serves the micro- and nanofabrication needs of multiple research groups in strategically important fields at NanoLund. The infrastructure is continuously updated and is supported by a dedicated team of highly educated lab personnel. LNL is also one node of the national infrastructure Myfab, whose mission is to provide Swedish researchers, entrepreneurs, and industry with leading-edge micro- and nanofabrication equipment. Myfab has important collaborations with the Nordic Nanolab Network (NNN).

LNL had 112 active academic users from 32 different research groups representing multiple faculties at Lund University, three institute users and 20 commercial users from six companies during the year. There were 44 new users receiving introductory training to LNL. The number of hours booked by academic groups and companies is lower than pre-pandemic levels, which can be somewhat attributed to delays in getting spare parts and repairing some key equipment that regulate wider lab use. European and national programmes like the EU Chips Act, EU Quantum Flagship, WACQT and WISE will all lead to the expansion of strong areas of research using the infrastructure.

Intense work is ongoing with the process of establishing a new Nanolab at Science Village. The new Nanolab will be the third major research facility at Brunnshög, alongside MAX IV and ESS. One part of this work is to secure equipment funding. In 2022, LNL gratefully received funding from the Crafoord Foundation to co-fund a Plasma Enhanced Chemical Vapour Deposition (PECVD) for high-quality silicon nitride thin film deposition (co-funded by LU) and funding for a versatile X-Ray Diffraction (XRD) to measure, for example, the structure of MOVPE grown layers. We have also been granted funding from the Olle Engkvist Foundation. As an initial engagement from the Foundation, we have received funding for a new scanning electron microscope (SEM) with energy dispersive X-ray spectroscopy (EDS) to measure the composition of nanoparticles.

In 2022, new tools installed in the clean room by the LNL team include an ellipsometer for measuring resist layer thickness and a new atomic layer deposition (ALD) tool used for depositing a material one atomic layer at a time to build up a very thin film of, for instance, an insulating material. The procurements of several new tools is underway or have been completed.

KEY FEATURES OF LNL

- Fabrication and analysis of structures on nanometer-scale
- Integration between epitaxy and processing
- Open clean room facility for academic research and companies
- 300 m² clean room for cutting edge nanofabrication
- Industrial product development and prototype testing

LNL NUMBERS IN 2022

299	Users with access
135	Active users
32	New users
32	Research groups
112	Research group users
5	Companies
20	Company users
3	Institute users
35 920	Booked hours

NanoLund is working to build Nanolab Science Village – a new, modern clean-room laboratory that will offer researchers unique opportunities to provide humanity with new knowledge for a sustainable society. Nanolab Science Village will be the first step towards establishing Lund University's presence in the burgeoning Science Village, located between the research infrastructures MAX IV and ESS, and will be followed by the creation of a campus. Photo: Atkins

LUND NANO CHARACTERIZATION LABS

NanoLund includes an extensive range of cutting-edge characterization instruments and techniques, ranging from microscopes capable of single-atom imaging to ultrafast spectroscopy laboratories that are tracking processes on a femtosecond time scale. These characterization laboratories are distributed all across Lund University.

Researchers at NanoLund are carrying out groundbreaking methodological developments in areas such as electrical and optical nano-characterization, multidimensional laser spectroscopy, scanning probe microscopy, transmission electron microscopy, synchrotron-based imaging, spectroscopy and scattering, nanosafety, biomechanics, as well as many-body and transport theory. Cornerstones of our success are the development of cutting-edge characterization methods and the enthusiastic sharing of expertise and knowledge. To strengthen and coordinate these efforts, Lund Nano Characterization Labs was created in 2009.

With the new possibilities opened up by the planned move to Science Village, the vision is to enhance the combined use of complementary characterization techniques. Plans are ongoing for how to locate laboratories from different groups closer together, and multiple informal meeting points for the involved scientists shall be created.

The NanoLund community also uses major cutting-edge characterization tools at synchrotron facilities, such as MAX IV in Lund, and free electron lasers. NanoLund members are also frequent users of neutron facilities worldwide and collaborate with the ESS (European Spallation Source). Additionally, some members are actively involved in developing new instrumentation at MAX IV and other large-scale research infrastructures.

NCHREM – NATIONAL CENTER FOR HIGH-RESOLUTION MICROSCOPY

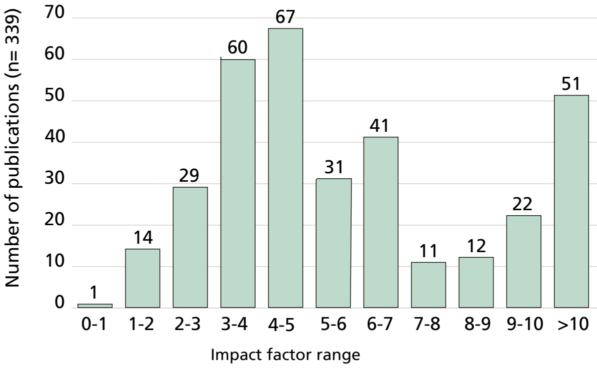
The nCHREM facility is situated at Kemicentrum at Lund University. Here state-of-the art atomic-level imaging, element analysis, and sample preparation for hard materials, biological materials and even liquids is performed. nCHREM provides electron microscopes for analytical high resolution work, surface imaging (SEM), Cryo-TEM for sensitive samples and a unique Environmental TEM where chemical reactions and crystal growth can be performed at high temperatures, while recording videos with atomic resolution, simultaneously with element analysis. A plunge-freezing facility for liquids is provided for preparing specimens for imaging at cryogenic temperatures. The active time on the available instruments is well distributed between many different users within Lund University, external users and teaching. The nCHREM facility is a member of Lund Nano Characterization Labs.

Scientific publications

Our most important way of communicating results and providing value to the scientific community is through high-quality scientific publications in widely-cited peer-reviewed journals. In 2022, the number of publications was 428.

The quality of our publications remained high, with an averaged journal impact factor (JIF) of 7.25, averaged over all our publications relevant to nanoscience. 14% of these publications were published in journals with a journal impact factor larger than 10. The overall distribution of the journal impact factor remains similarly shaped compared to the last years. We consider it a good sign that we have a balance between high-impact factor papers with high visibility and publications in archival journals peaking at an intermediate impact factor of around 3 to 4. This indicates a healthy mixture of specialized, in-depth research with visionary high-impact studies.

Journal impact factor distribution for NanoLund publications in 2022 (339 of the 366 nanoscience publications have a defined JIF)



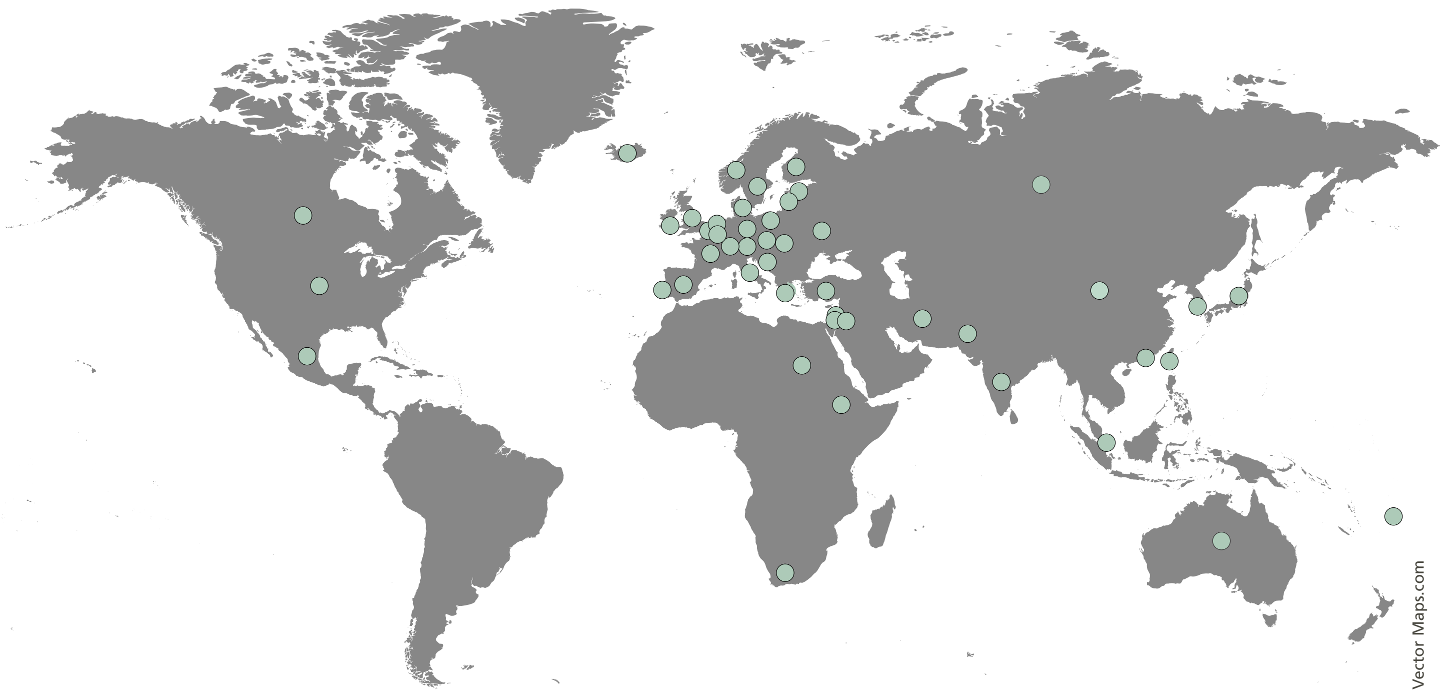
PUBLICATIONS 2022

428 Publications in total

366 Publications directly related to nanoscience

51 Nanoscience publications with journal impact factor > 10

7.25 Average journal impact factor



In 2022 NanoLund researchers co-published with researchers at 397 international institutions in 47 different countries and with 16 Swedish universities.

NanoLund Awards

NANOLUND AWARD FOR EXCELLENT TECHNICAL AND ADMINISTRATIVE SUPPORT

The outstanding work done by our technical and administrative staff is of critical importance for NanoLund and without which none of our research and teaching would be possible. The award for excellent technical and administrative support recognizes special achievements of technical and administrative personnel.

Patrik Wirgin, Finance officer, Synchrotron Radiation Research
Sungyoun Ju, Research engineer, Solid State Physics

NANOLUND YOUNG TEACHER AWARD

The efforts of junior staff are often crucial for the courses we teach and help form the impression undergraduate students have of our research environment. The young teacher award recognizes the extraordinary commitment to teaching by junior scientists.

David Alcer, PhD student, Solid State Physics
Linnéa Jönsson, PhD student, Solid State Physics

NANOLUND JUNIOR SCIENTIST IDEAS AWARD

The junior scientist ideas award is presented to the young researchers who are granted NanoLund seedling projects; proposals for novel research projects submitted by master's students, PhD students and postdocs at NanoLund. The grantees are selected based on the originality, feasibility, potential impact and initiative of their proposed project from across all research areas of NanoLund.

In 2022, 20 seedling project applications were received and evaluated by a group of senior scientists. Four projects were selected for funding by a sum of SEK 100 000 per project.

Linnéa Jönsson and **Linnea Lindh,** Solid State Physics and Chemical Physics – Tailored Metal Oxide Nanoparticles for improved solar cell electron extraction.
Mikelis Marnauza and **Robin Sjökvist,** Centre for Analysis and Synthesis – In-situ growth of GaSb nanowires.
Ruben Seoane Souto, Solid State Physics – Andreev bound states in the continuum.
Tania Lima, Biochemistry and Structural Biology – The role of nanoparticle size in Dectin-1 protein activation: a nano-approach to control host deleterious inflammation.

NANOLUND DISTINCTION FOR PHD STUDENTS

NanoLund Distinction is awarded to a PhD student graduating within the NanoLund environment who has shown particular dedication to research, education and outreach activities, who has acquired a broad knowledge of nanoscience research and its societal relevance and impact and who has demonstrated research independence and leadership beyond what is in general required for a PhD degree in Sweden.

Sven Dorsch, Solid State Physics
Lukas Hrachowina, Solid State Physics
Yen-Po Liu, Synchrotron Radiation Research

Photo: Evelina Lindén

The coming generation of nano-scientists

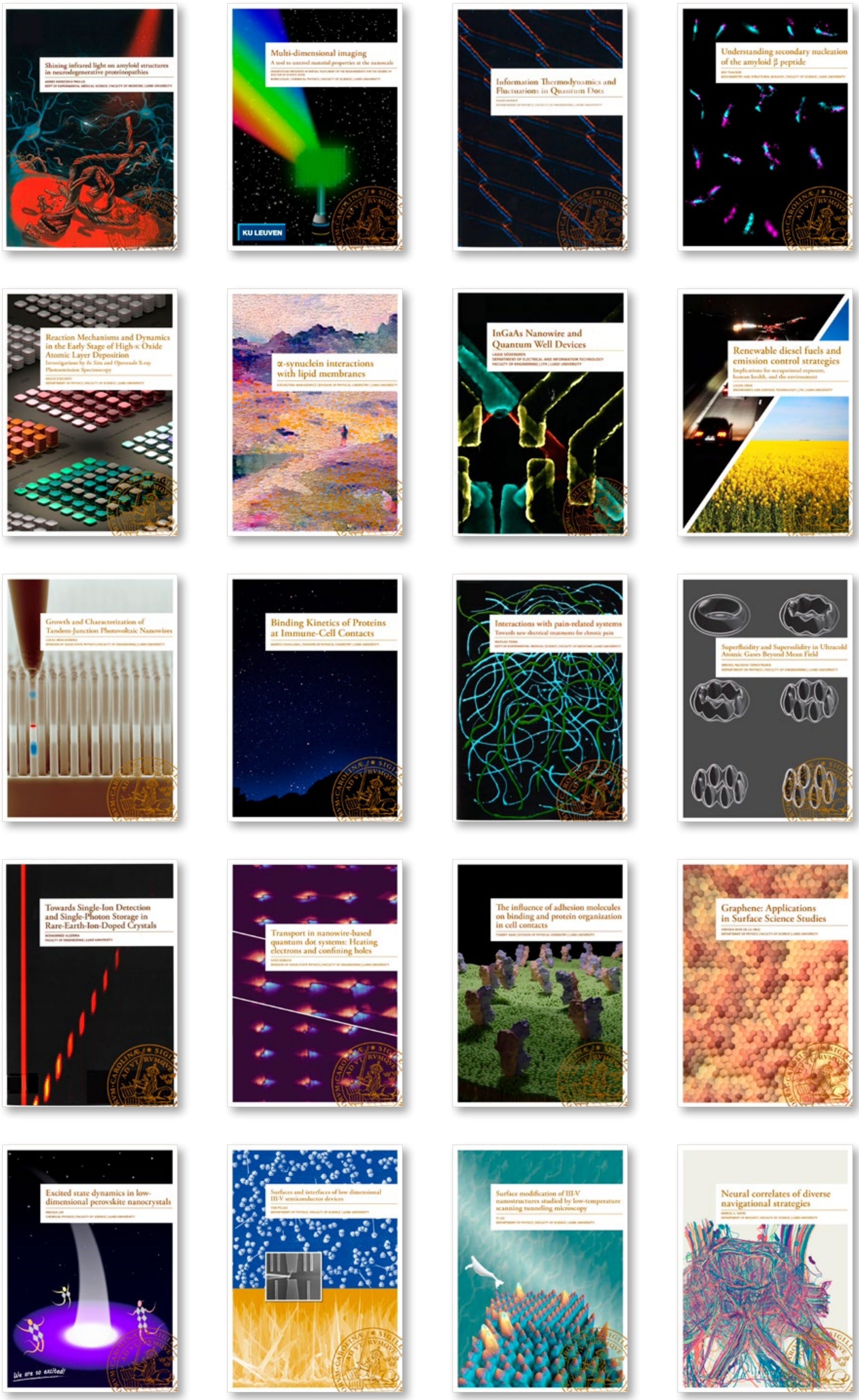
NanoLund is Sweden's largest research environment for interdisciplinary nanoscience and nanotechnology. In 2022, we engaged more than 160 PhD students in sciences ranging from engineering to natural sciences and medicine. The PhD students constitute roughly one-third of the staff engaged in NanoLund and are an important and integrated part of our research environment.

In 2022, 23 NanoLund PhD students successfully defended their theses. We wish them all the best for their future careers.

NANOLUND PHD THESES DEFENDED DURING 2022

More information can be found on our web page, nano.lu.se/previous-phd-theses

Agnes Paulus	Medical Microspectroscopy	*Shining infrared light on amyloid structures in neurodegenerative proteinopathies*
Alexander Bengtsson	Atomic Physics	*Material and technique development for ultrasound optical tomography using spectral hole burning filters*
Boris Louis	Chemical Physics	*Multi-dimensional imaging*
David Barker	Solid State Physics	*Information Thermodynamics and Fluctuations in Quantum Dots*
Dev Thacker	Biochemistry and Structural Biology	*Understanding secondary nucleation of the amyloid β peptide*
Giulio D'Acunto	Synchrotron Radiation Research	*Reaction Mechanisms and Dynamics in the Early Stage of High-κ Oxide Atomic Layer Deposition*
Hafsa Syed	Atomic Physics	*Nuclear spin interactions and coherent control in rare-earth-ion-doped crystals for quantum computing*
Ivan Sytcevich	Atomic Physics	*Generation, characterization and application of infrared few-cycle light pulses*
Katarzyna Makasewicz	Physical Chemistry	*α-synuclein interactions with lipid membranes*
Lasse Södergren	Nano Electronics	*InGaAs Nanowire and Quantum Well Devices*
Louise Gren	Ergonomics and Aerosol Technology	*Renewable diesel fuels and emission control strategies*
Lukas Hrachowina	Solid State Physics	*Growth and Characterization of Tandem-Junction Photovoltaic Nanowires*
Manto Chouliara	Physical Chemistry	*Binding Kinetics of Proteins at Immune-Cell Contacts*
Matilde Forni	Neuronano Research Center	*Interactions with pain-related systems – Towards new electrical treatments for chronic pain*
Mikael Tengstrand Nilsson	Mathematical Physics	*Superfluidity and Supersolidity in Ultracold Atomic Gases Beyond Mean Field*
Mohammed Alqedra	Atomic Physics	*Towards Single-Ion Detection and Single-Photon Storage in Rare-Earth-Ion-Doped Crystals*
Shuo Yang	Heat Transfer	*Microfluidic Hydrodynamic of Gas-Liquid flow in Single Microchannel and Porous Media with Microchannel Network*
Sven Dorsch	Solid State Physics	*Transport in nanowire-based quantum dot systems: Heating electrons and confining holes*
Tommy Dam	Physical Chemistry	*The influence of adhesion molecules on binding and protein organization in cell contacts*
Virginia Boix	Synchrotron Radiation Research	*Graphene: Applications in Surface Science Studies*
Weihua Lin	Chemical Physics	*Excited state dynamics in low-dimensional perovskite nanocrystals*
Yen-Po Liu	Synchrotron Radiation Research	*Surfaces and interfaces of low dimensional III-V semiconductor devices*
Yi Liu	Synchrotron Radiation Research	*Surface modification of III-V nanostructures studied by low-temperature scanning tunneling microscopy*



A selection of cover pages from NanoLund theses 2022.

How we are organized

NanoLund is headed by a Board, which defines strategy and makes formal decisions. The center is advised by an international Scientific Advisory Board and an External Advisory Council with members from society, academia and industry. Our research is organized into research areas and we have three resource areas that enable and complement the scientific work.

HISTORY

2022 Launch of LTH profile area Nanoscience and Semiconductor Technology

Launch of LU profile area Light and Material

2020 New strategic plan

2016 NanoLund forms a vision and starts strategic work for establishment at Science Village

2015 The strategic research area becomes NanoLund, the Centre for Nanoscience at Lund University

2009 Strategic research area selected by the Swedish Government

2007 Inauguration of Lund Nano Lab

2003 Starting the new education program Engineering Nanoscience (BSc and MSc)

1995 SSF funds nmC with several significant grants until 2012

1988 The Nanometer Structure Consortium (nmC) is initiated

BOARD

Heiner Linke (Chair), *Deputy Dean, Faculty of Engineering, Lund University* | **Elizabeth Blackburn,** *Faculty of Science, Lund University* | **Erik Lind,** *Faculty of Engineering, Lund University* | **Kerstin Jakobsson,** *CEO Kongsberg Beam Technology AS* | **Kimberly Dick Thelander,** *Faculty of Engineering, Lund University* | **Kristian Pietras,** *Faculty of Medicine, Lund University* | **Mats Qvarford,** *Strategic Partnership Manager, Tetra Pak* | **Peter Honeth,** *Chair MAX IV Laboratory Board* | **Tõnu Pullerits,** *Faculty of Science, Lund University* | **Jonatan Fast,** *student representative, Lund University* | **Linnéa Jönsson,** *student representative, Lund University* | **Marcus Lindén,** *student representative, Lund University*

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COORDINATORS' FORUM

The coordinators' forum is made up of the coordinators for the NanoLund research and resource areas, the members of the management group, the chair of the board and the student representatives of the board.

NANOLUND SCIENTIFIC ADVISORY BOARD


Robert Feidenhans'l


Stephen Goodnick


Chris Palmstrøm


Heike Riel


Friedrich Simmel


Ulla Vogel


Martin Wolf

How we have developed

In 2022, 441 persons were involved in NanoLund as principal investigator (PI), researcher, PhD student or technical and administrative staff. The majority is distributed over three faculties at Lund University and MAX IV, and about 6% of NanoLund staff is affiliated to institutions other than Lund University. Of the PI:s, the number of Faculty Members and Affiliated Faculty Members were 59 and 50, respectively. The average level of engagement in NanoLund in 2022 was 65%, corresponding to 268 full-time equivalents.

In the past years, we have seen an increased interest in collaborating and becoming a part our research environment. Since NanoLund became a strategic research area in 2009, the number of postdocs and PhD students has tripled. In contrast, the number of PIs (Faculty and Affiliated Faculty Members) have remained approximately constant, an indication that the NanoLund research groups are thriving. This is also shown by the increasing external funding, i.e research grants won in competitive calls. The number of publications keeps increasing.

Gender balance

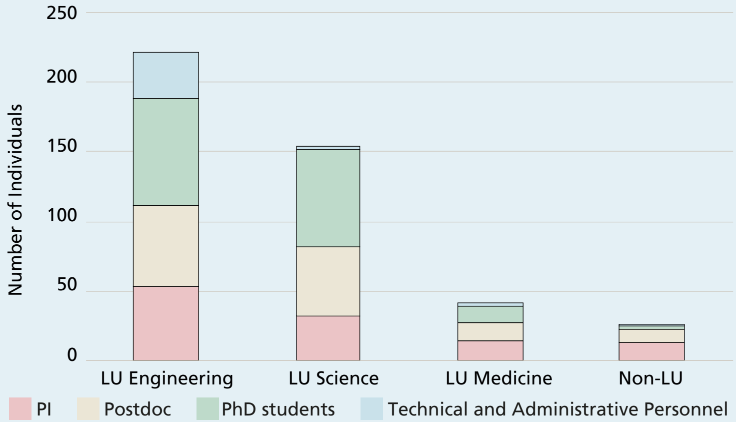
NanoLund strives for gender balance and for being a diverse and inclusive workplace. Overall, 33% of the total staff at NanoLund are women.

The proportion of women among Faculty and Affiliated Faculty Members has incresead this year. We will continue taking actions to keep improving the gender balance at all levels over the following years as we work with faculties and departments on even better and more diverse recruitment.

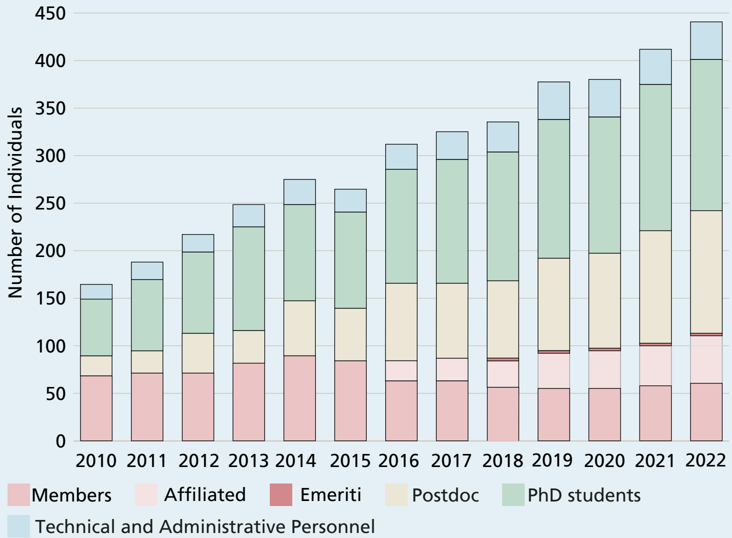
GENDER STATISTICS FOR ACADEMIC POSITIONS IN 2022

PI:s	24% women	76% men
Postdocs	30% women	70% men
PhD students	36% women	64% men

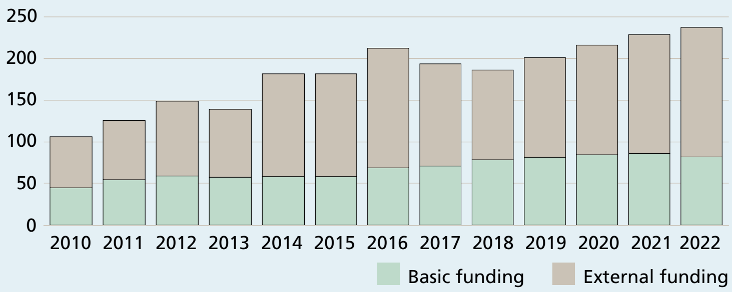
NanoLund staff by faculty



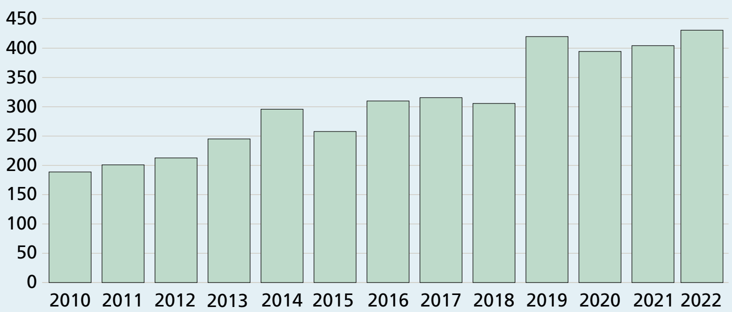
Personnel trends 2010–2022



Funding over time (MSEK)



Total number of publications over time



Funding

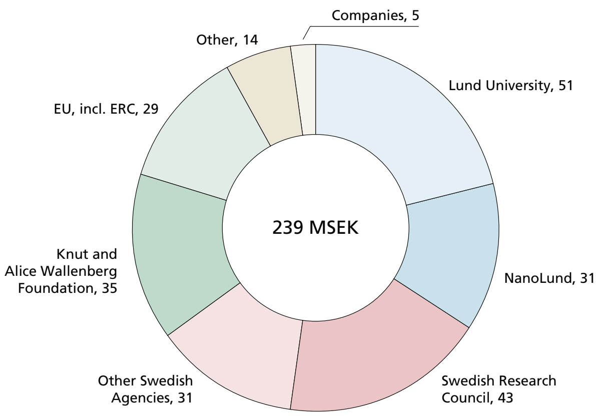
NANOLUND INCOME SOURCES

Funding for NanoLund and our researchers comes from a range of national and international funding agencies. This combination ensures that our interdisciplinary environment has the necessary resources to conduct nanoscience research at the highest international standard.

The total income is assessed as direct funds to NanoLund and our faculty members' income, weighted with their degree of participation in NanoLund.

In 2022 the total income for NanoLund was SEK 239 million. This is an increase of SEK 6 million compared to 2021 and is mainly due to an increase in the amount of external funding our researchers have won in competitive calls. SEK 82 million came from Lund University, of these SEK 31 million are strategic research area funding for NanoLund. SEK 157 million, corresponding to 66% of the total income, was external funding won in competitive calls. See the diagram below for the distribution of funding from individual income sources.

NanoLund income sources 2022 (MSEK)



FUNDING HIGHLIGHTS

NanoLundians are active and successful in applying for externally funded grants, and many holds highly prestigious grants. In 2022, NanoLund grantees included:

- 14 active European Research Council (ERC) grants (in total 18 NanoLundians have received ERC grants since the start of the strategic research area)
- Participation in 18 EU-projects
- Coordination of 4 of our 18 EU-projects
- 4 Wallenberg Scholars
- 2 Knut and Alice Wallenberg (KAW) project grants
- 1 Novo Nordisk Foundation Excellent Research Leader
- 3 Swedish Research Council Distinguished Professors
- 3 Swedish Research Council Research Environments
- 2 Future Research Leaders from the Swedish Foundation for Strategic Research, SSF
- 1 Strategic Mobility Grant from SSF

Thanks to our funders

AFA Insurance
Alfred Österlunds Siftelse
Cancerfonden
Carl Tryggers stiftelse för vetenskaplig forskning
Crafoord Foundation
Danish Council for Strategic Research
Danish Offshore Technology Centre
Emil och Wera Cornells Stiftelse
European Commission's Research and Innovation Activities: European Research Council (ERC), Marie Skłodowska-Curie Actions, Horizon 2020 and Horizon Europe
FORMAS – Swedish Research Council for Sustainable Development
Forte, the Swedish Research Council for Health, Working Life and Welfare
FQXi (Foundational Questions Institute)
Hjärnfonden – the Swedish Brain Foundation
Independent Research Fund Denmark
Kamprad Family Foundation for Entrepreneurship, Research & Charity
Knut and Alice Wallenberg Foundation
LMK Foundation for Interdisciplinary Scientific Research
Magn. Bergvalls Stiftelse
Mats Paulssons Stiftelse för forskning, innovation och samhällsbyggande
MISTRA, the Swedish Foundation for Strategic Environmental Research
Novo Nordisk Foundation
Office of Naval Research
Olle Engkvists Stiftelse
Region Skåne
Royal Physiographic Society of Lund
Ruth och Nils-Erik Stenbäcks stiftelse
Sanofi
Seco Tools AB
Sida – Swedish International Development Cooperation Agency
Stiftelsen Kronprinsessan Margaretas Arbetsnämnd för synskadade (KMA)
STINT – The Swedish Foundation for International cooperation in Research and Higher Education
Sven och Ebba-Christina Hagbergs Stiftelse
Swedish Agency for Economic and Regional Growth
Swedish Alzheimer's foundation
Swedish Energy Agency
Swedish Environmental Protection Agency
Swedish Foundation for Strategic Research, SSF
Swedish Heart-Lung Foundation
Swedish Research Council
Swedish Water Research
Swedish Work Environment Authority
Swedish-Norwegian Foundation for Equine Research
TetraPak
Vinnova – Sweden's innovation agency
VolkswagenStiftung
ÅForsk
Åke Wibergs stiftelse

Photo: Evelina Lindén

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The NanoLund Annual Report 2022 presents highlights, progress, data, statistics and trends for the research environment in 2022.

This report is based on material and data compiled and edited by the staff of NanoLund, in particular: **Mirja Carlsson Möller,** Center Coordinator | **Evelina Lindén,** Communication | **Anna-Karin Alm,** External Relations Officer | **Gerda Rentschler,** Project Coordinator | **Anneli Löfgren,** Administrative Director | **Anders Mikkelsen,** Director | **Maria Messing,** Deputy Director

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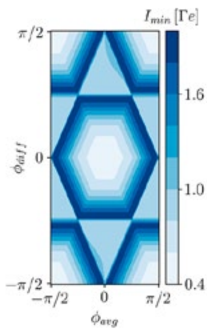
On the cover: This plot, made by NanoLund PhD student Maximilian Nitsch, is based on data obtained via a numerical simulation of electron transport through a Majorana box Qubit. It represents the Fano factor of the current running through the box. The x-y-direction represents magnetic fluxes adjusting the transport into a parity blockade inside the white triangles. Just outside the blockade, at the dark blue boundary, the Fano factor maximizes to 2, meaning that electrons always tunnel in pairs. Funded by the European Research Council (ERC), Grant Agreement No. 856526.



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NanoLund
CENTER FOR NANOSCIENCE

LUND UNIVERSITY
NanoLund
Box 118
SE-221 00 Lund
www.nano.lu.se