effzett

FORSCHUNGSZENTRUM JÜLICH'S MAGAZINE

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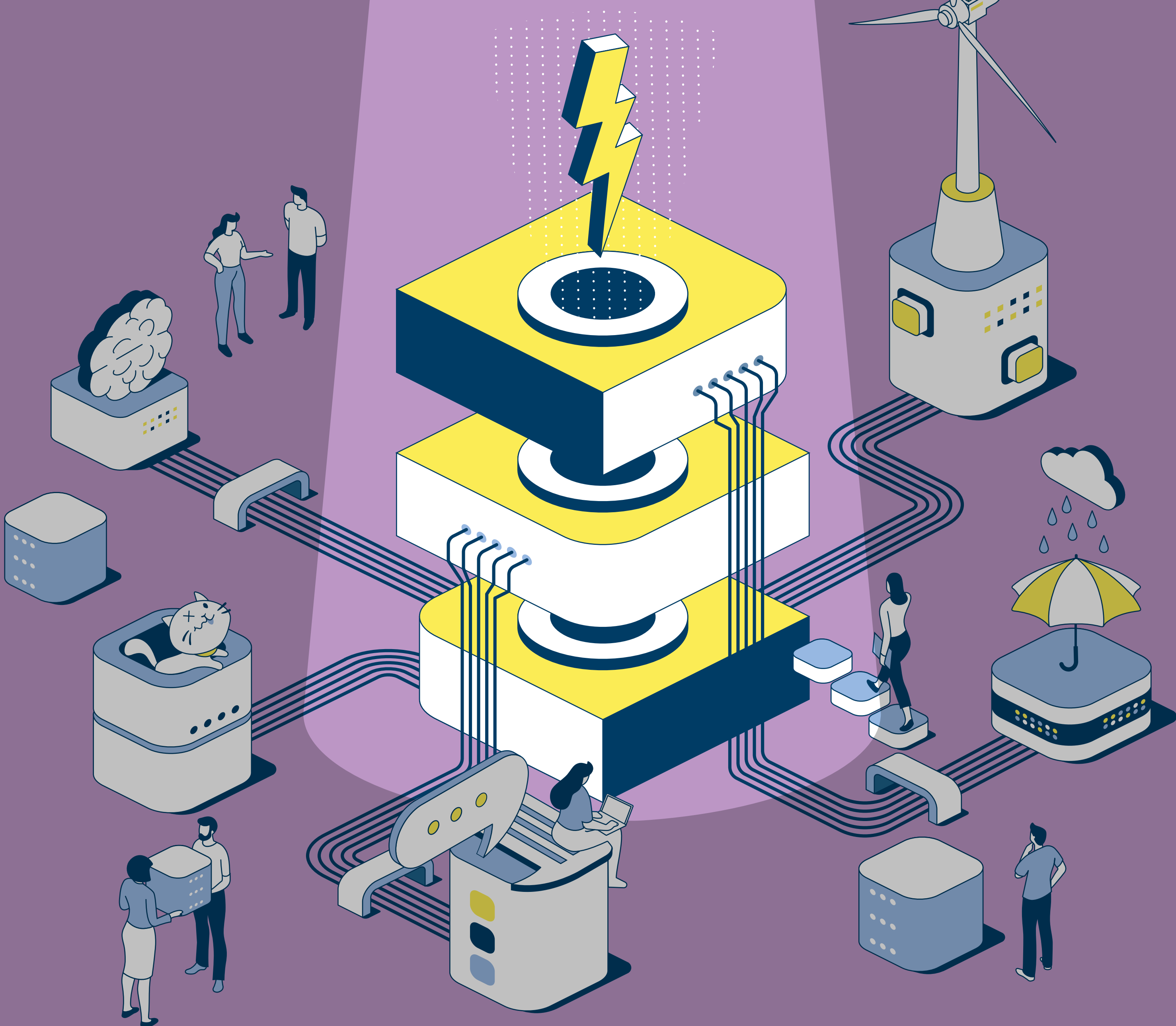


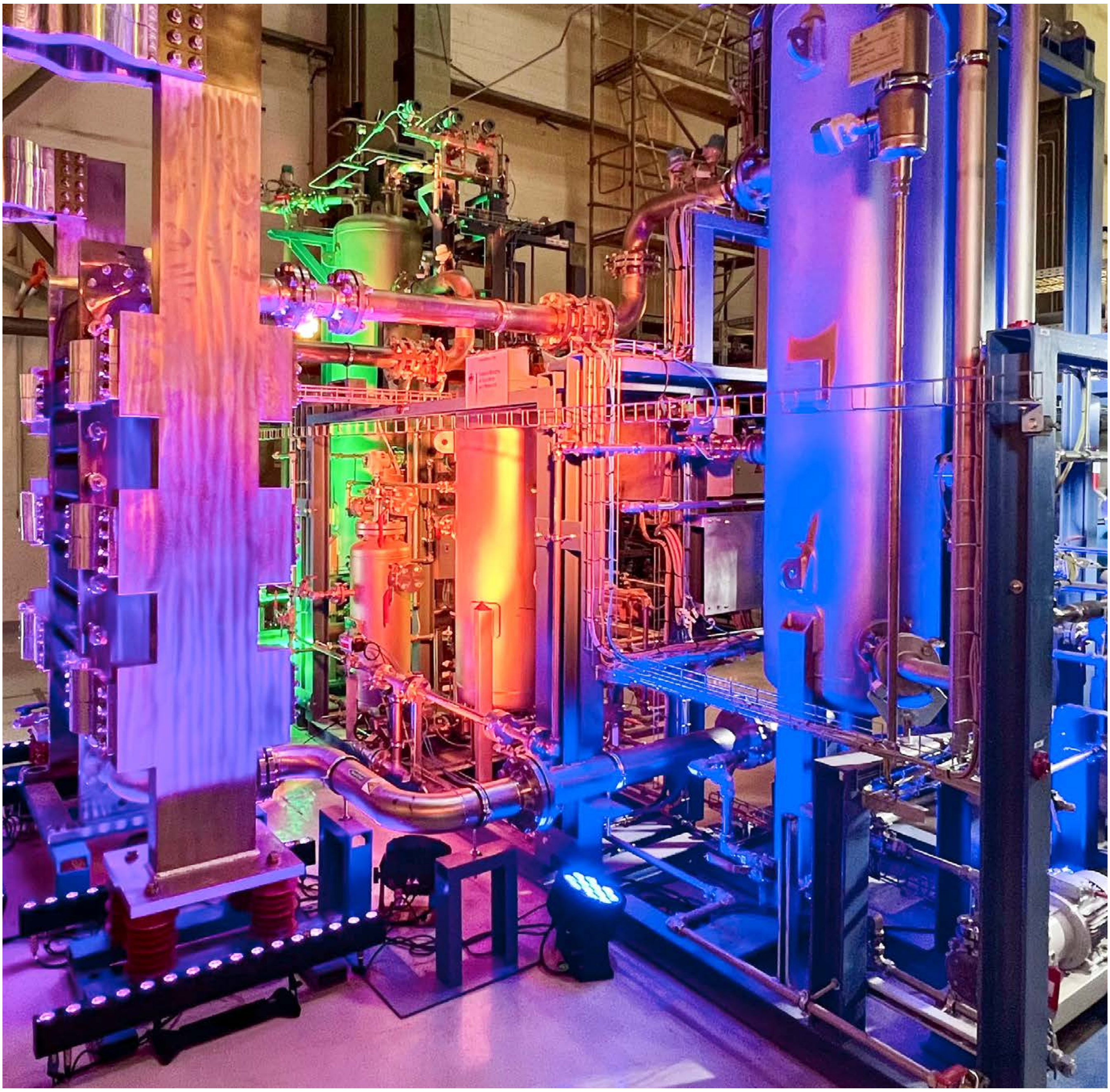
Spotlight on JUPITER

Jülich is home to Europe's first exascale computer

NO TIME?
In search of the internal clock in your head

CATCH ME!
How CO_2 can be removed from the atmosphere

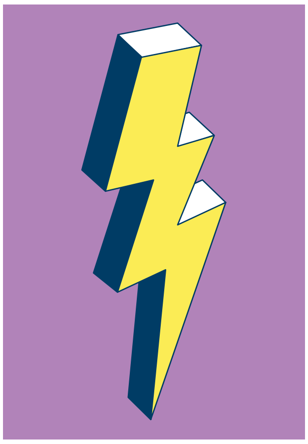
NOT FUSSED?
How brain structure and stress management are connected

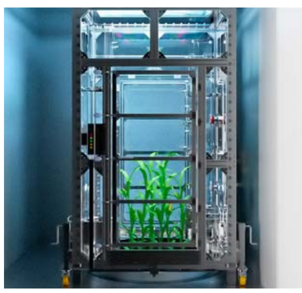


↑

Research on a real scale

The new showpiece on the Jülich campus is bright and colourful. The test stand will be used to develop more efficient and cost-effective electrolyzers for hydrogen production. The most important colour shimmers in the background: green. After all, the hydrogen in question is also green. Green means that it is generated using electricity from renewable sources only. The electrolyzers being tested are particularly suited to this task thanks to a special polymer membrane. What makes the project unique is that the electrolyzers in the test stand do not run on a laboratory scale but on an industrial scale. The facility is part of the DERIEL project, which is part of the national H_2Giga flagship project.





Time for history

Progress is not necessarily dependent on how many people work on a project. In August 1963, the Control Data Corporation introduced its new high-performance computer, the CDC 6600, which was able to calculate three times faster than the forerunner at the time, the IBM 7030 Stretch. Alarm bells rang at IBM. In an internal memo, the then chairman of the board, Thomas Watson Jr., vented his displeasure at the fact that IBM had lost its leadership position to a company with just 34 employees, including the janitor. At the time, more than 170,000 people worked at IBM. The “janitor memo” can be seen today at the Computer History Museum in San José, USA.

Historical developments are also on the horizon at Jülich. Europe’s first exascale supercomputer is being built here – a great-great-great-grandchild, so to speak, of the CDC 6600. In our cover story, we present the new possibilities that this multitalented computer will open up in the future, for example in the fields of climate research, artificial intelligence, and quantum computing. And we also look to the future in other articles in this issue. For example, we discuss the need for recycling concepts for emerging organic electronics and technologies for removing CO_2 from the atmosphere. If you have a little more time on your hands, you can also learn about our perception of time. There appears to be a special neural pattern in the human brain for this.

We hope you enjoy a relaxing read!
Your effzett editorial team

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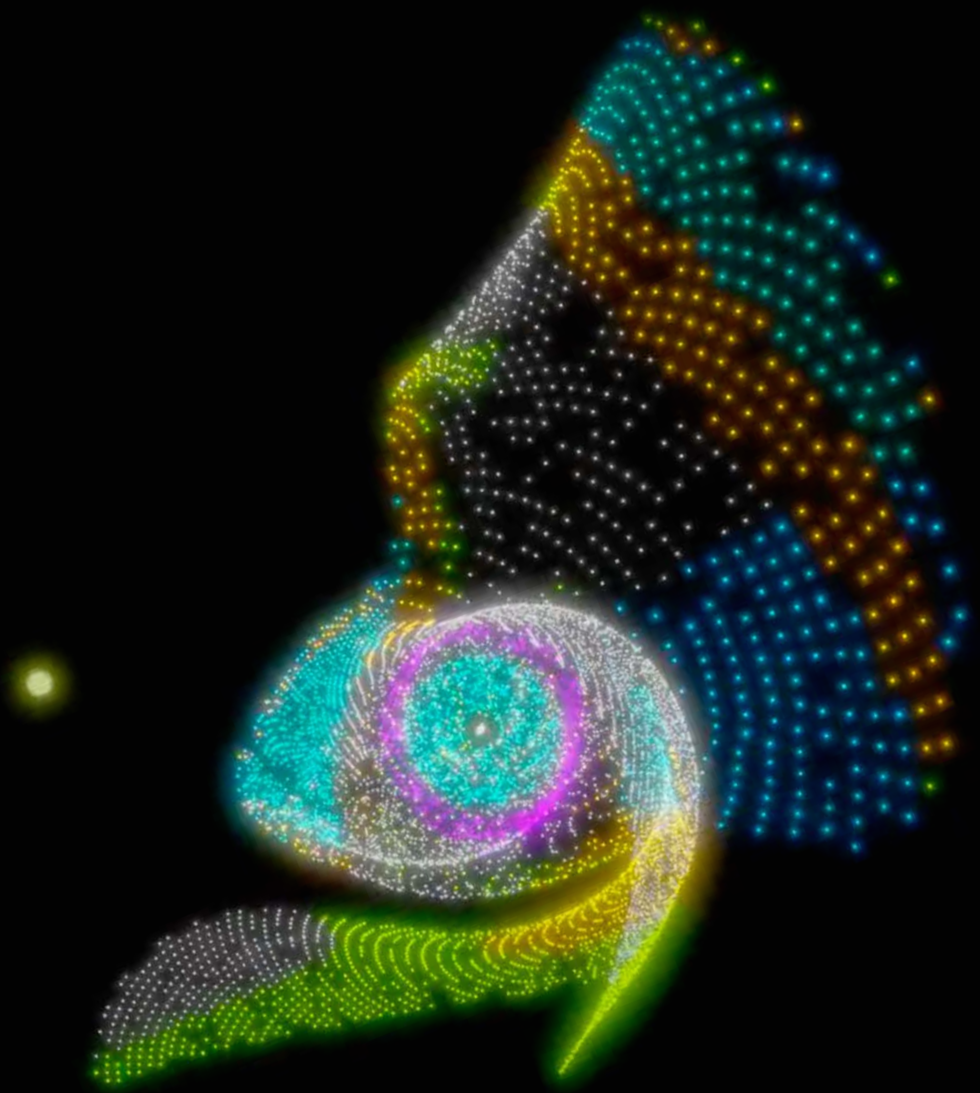
ASTROPHYSICS

Deflected

Strange things are happening at the edge of our solar system. Some dwarf planets and smaller objects are not revolving around the sun in typical circular orbits. Instead, they are moving in inclined, elongated orbits. To date, there has been no explanation for this. However, computer simulations by astrophysicists from Jülich and Leiden (the Netherlands) now suggest that billions of years ago, a star may have passed very close to our solar system, changing the trajectories of a number of celestial bodies.

– JÜLICH SUPERCOMPUTING CENTRE –

Link to video:
go.fzj.de/effzett-Astromeldung



ACCOLADE

Appointed to Leopoldina

Prof. Gereon R. Fink, a neurologist and neuroscientist, has been appointed a new member of the German National Academy of Sciences Leopoldina. Fink, director at the Jülich Institute of Neuroscience and Medicine and Professor of Neurology at the University of Cologne, investigates neurological diseases such as strokes, Parkinson's disease, and dementia with the aim of improving diagnosis and treatment.

– INSTITUTE OF NEUROSCIENCE AND MEDICINE –

BRAIN RESEARCH

New regions show stronger signs of ageing

In humans, the brain regions that have expanded most recently in the course of evolution show the strongest ageing effects. This is evident from comparisons with brain ageing in our closest relatives, chimpanzees. Areas that are responsible for higher cognitive functions age particularly quickly. These include working memory and abilities such as long-term planning and self-regulation. For the study, the researchers from Jülich and Düsseldorf used existing brain scans, which they analysed with a new method for recognizing brain patterns.

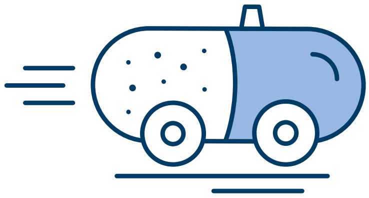
– INSTITUTE OF NEUROSCIENCE AND MEDICINE –

MEDICINE

Taxi, please!

Medication is often administered in the form of tablets or injections. The active ingredient then often has a long way to travel to the target location in the body. During this journey, it can cause side effects. Jülich scientists have now developed a "drug taxi" that delivers a substance in a well-packaged form directly to the desired location and only releases it there. Packaging and transport are provided by tiny nanoparticles that release the active ingredient in response to a signal – for example, a certain oxygen content or pH value. The "taxi" was proven to work in laboratory tests with insulin. Tests with blood and tissue samples are still pending.

– JÜLICH CENTRE FOR NEUTRON SCIENCE –



5.8

million euros

is being provided by the German Research Foundation (DFG) for a further three years for the priority programme SPP 2330. In the programme, which has been running since 2021, scientists are researching bacteriophages – viruses that infect bacteria and are considered a possible alternative to antibiotics in the fight against multi-resistant germs. Jülich microbiologist Prof. Julia Frunzke is coordinating the programme.

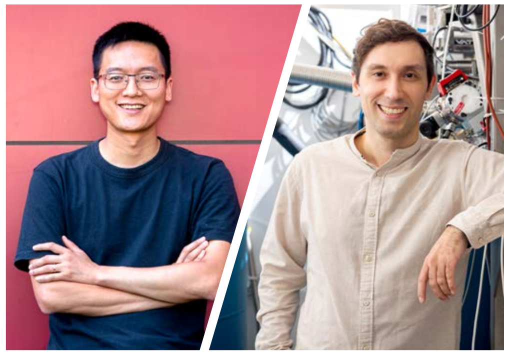
– INSTITUTE OF BIO- AND GEOSCIENCES –

ARTIFICIAL INTELLIGENCE

Problems with logical thinking

AI language models – also known as large language models (LLMs) – often fail when confronted with logical questions. Jülich and English researchers from the AI laboratory LAION and the Open-Ψ (Open-Sci) Collective had set a variety of current LLMs with a number of simple tasks – for example *"Alice has four brothers and one sister. How many sisters does Alice's brother have?"* The correct answer is two. The models answered this and similarly simple questions incorrectly in more than half the cases. And their performance fluctuated greatly with only slightly modified tasks. For the authors of the study, this indicates that the LLMs have fundamental deficits when it comes to generalization. They therefore call for the capabilities of the current generation of LLMs to be correctly measured and re-evaluated. Furthermore, uniform standards should be developed to uncover weaknesses in language models with regard to their reasoning ability.

– JÜLICH SUPERCOMPUTING CENTRE –



RESEARCH AWARD

ERC Grants to Jülich researchers

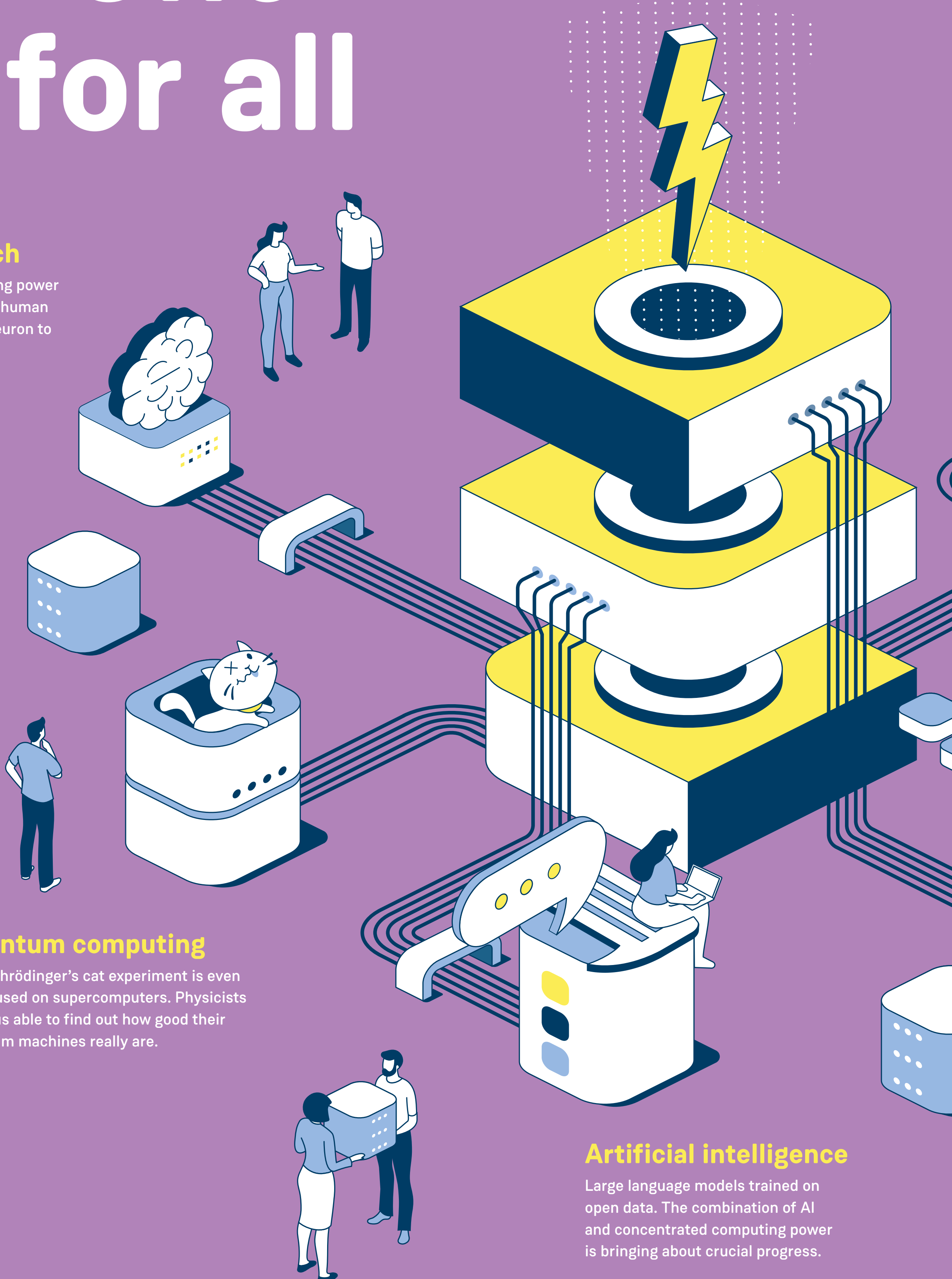
Dr. Jun Huang and Dr. Taner Esat have each received a Starting Grant of up to € 1.5 million from the European Research Council (ERC). Jun Huang from the Institute of Energy Technologies, who is also a junior professor at RWTH Aachen University, is researching nanoparticle catalysts that are needed as part of the energy transition for the rapid and economical conversion of electricity into chemical energy. Taner Esat from the Peter Grünberg Institute is developing a mobile quantum system that can be used, for instance as a quantum sensor to measure physical quantities on an atomic scale (see also p. 31).

Stay up to date!

In our monthly newsletter, Jülich News, you can read about the latest developments from FZJ by email (in German). Subscribe to the newsletter now!

go.fzj.de/effzett-newsletter

One for all



Brain research

Concentrated computing power is used to simulate the human brain – from a single neuron to a neural network.

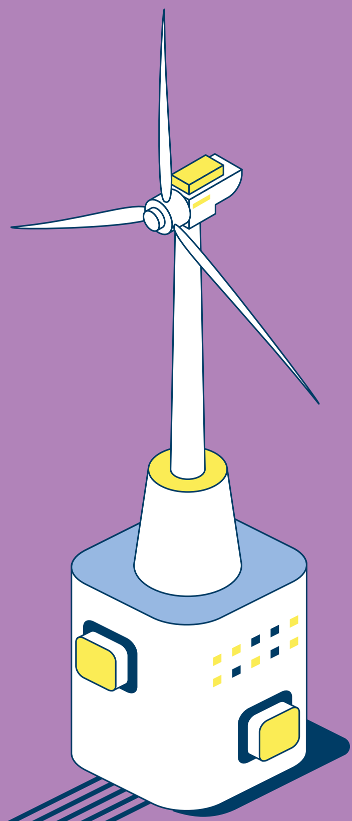
Quantum computing

The Schrödinger's cat experiment is even being used on supercomputers. Physicists are thus able to find out how good their quantum machines really are.

Artificial intelligence

Large language models trained on open data. The combination of AI and concentrated computing power is bringing about crucial progress.

Europe’s first exascale computer is set to be launched at Jülich, JUPITER. The versatile supercomputer will be one of the world’s most powerful AI machines and opens up new possibilities for simulating complex systems. Its applications range from the quantum cosmos to issues relating to the energy transition.



Energy research

Whether it be a wind turbine, hydrogen turbine, or battery pack, the exact flow model of the high-performance computer can also be turbulent.

Climate research

As accurate as tomorrow’s weather forecast: how will the global climate develop over the next 20 or 30 years?

Further information on JUPITER:
go.fzj.de/effzett-jupiter-EN

The first supercomputer in Europe was launched in 1965. The CDC 6600 at the CERN research centre was able to perform three million floating-point operations per second. Any current smartphone would exceed this performance by countless orders of magnitude. And now, 60 years later, the great-great-great-grandchild of CDC 6600, JUPITER, is being launched at the Jülich Supercomputing Centre (JSC). It will be the first computer in Europe to surpass the magical threshold of one quintillion (a “1” followed by 18 zeros) floating-point operations per second. That is roughly equivalent to the performance of around one million modern smartphones, or around a trillion CDC 6600s. This makes JUPITER an exascale-class supercomputer.

But JUPITER’s record speed is not an end in itself. The simulations performed on the powerful supercomputer will provide insights that cannot be gained through purely experimental or theoretical means. JUPITER is a technological all-rounder that can handle a wide range of different applications. These applications address some of the biggest challenges of the future from the smallest to the largest scale – from the behaviour of individual quanta to global climate models, and from molecular processes in neurons to large language models.

JUPITER’s flexible architecture enables a wide range of applications. The supercomputer’s Booster module works on the basis of graphics processing units (GPUs), which are particularly suitable for a variety of highly parallel applications, as presented here. The Cluster module, in contrast, is suitable for more variable tasks with complex execution patterns, such as some physics simulations of interactions between elementary particles in atomic nuclei. With this approach, JUPITER is well positioned to serve both classic high-performance computing (HPC) simulations and advanced artificial intelligence (AI) methods.

From weather forecasting to climate simulation

A typical application that would have been inconceivable for decades without the computing power of supercomputers is weather forecasting. Germany's National Meteorological Service (DWD) uses the ICON atmospheric model, a modular open-source software. The software can be used to calculate short periods of time with a high spatial resolution, enabling weather forecasts to be made for the coming days based on current measurements and observations. It is also possible to work with a lower resolution and simulate the development of the global climate over decades. "However, we want to look much further and more accurately into the future – creating detailed, long-term climate forecasts," explains meteorologist Dr. Sabine Griessbach (JSC).

How will the global average temperature change if we continue to pump CO_2 into the atmosphere? And what about extreme weather events? Will we experience heat waves more frequently in future? And with what intensity?

Thanks to JUPITER's computing power, ICON will be able to answer these questions with greater accuracy than ever before. The crucial advantage that JUPITER offers the model is a smaller mesh size. ICON covers the Earth in a grid of triangles. It then calculates the relevant parameters such as temperature, pressure, and humidity for each of these grid cells. The mesh size of the network indicates approximately how wide an individual triangle is. For current weather forecasts with ICON, the mesh size is around 13 kilometres. This means that phenomena with a smaller scale, such as clouds, can fall through the cracks, so to speak.

← Sabine Grießbach wants to use JUPITER to create detailed climate forecasts.

"With JUPITER, we can change that and simulate the future of the climate with a spatial resolution of about one kilometre," explains Dr. Lars Hoffmann (JSC), an expert in atmospheric research and modelling: "We can thus bridge the gap between weather and climate modelling. And extreme events such as violent thunderstorms and heavy rainfall will be depicted much more realistically on the computer than they are today." Initial work on this has already started on the JEDI test system.

JEDI is the first module of JUPITER. It already features the hardware that is planned for the JUPITER Booster module. As with the JUPITER Booster module, JEDI uses particularly efficient GPUs from the world's leading chip manufacturer, Nvidia.

An important aspect will be how the weather and climate models work with the latest generation of graphics cards used in JUPITER. "For example, many software libraries also need to be installed. We are currently in the process of configuring, testing, and optimizing them so that we can use the computer architecture as efficiently as possible," explains Grießbach.

Artificial intelligence on the supercomputer

Another application that can benefit from JUPITER and its Nvidia GPUs is machine learning. In particular, generative AI, which produces images and text, for example, has impressively demonstrated in recent years with language programs such as ChatGPT that these algorithms can come remarkably close to human language.

Large language models (LLMs) are trained with a multitude of texts. They use these texts to learn the probability of one word following another – and can thus form a meaningful sentence, word by word. The model must therefore memorize huge amounts of data on linguistic building blocks and how they are interconnected.

"A leap in the quality of these language models was only achieved when they were trained with numerous parameters on huge amounts of data. And that was only possible because high-performance computers were used," explains Chelsea Maria John (JSC). In a team focused on algorithms and methods for computing accelerators, such as JUPITER's GPUs from Nvidia, she works at the interface between AI and supercomputers.

Her main focus is an open-source language model that she is helping to develop in the OpenGPT-X project: "Behind this is a German network of ten project partners. They come from research, as well as from industry and the media. OpenGPT-X models should be able to handle different European languages, but especially German." The software for training such LLMs should also run on JUPITER. Its processors are tailor-made for AI.

"This makes it possible to train large language models much faster and more efficiently. However, we also have to ensure that the tasks are distributed evenly across all processors," says John.

The 24,000 GPUs in the Booster module are designed to process data in a highly parallel manner. In contrast, conventional processors (CPUs) are particularly good at performing complex calculations in rapid succession. To perform these calculations, they have a small number of powerful processing cores. GPUs, on the other hand, have more processing cores that are not quite as powerful, but which work hand in hand simultaneously. This parallel computing allows them to perform the relatively simple individual operations that are carried out for AI, for example, faster than conventional processors.

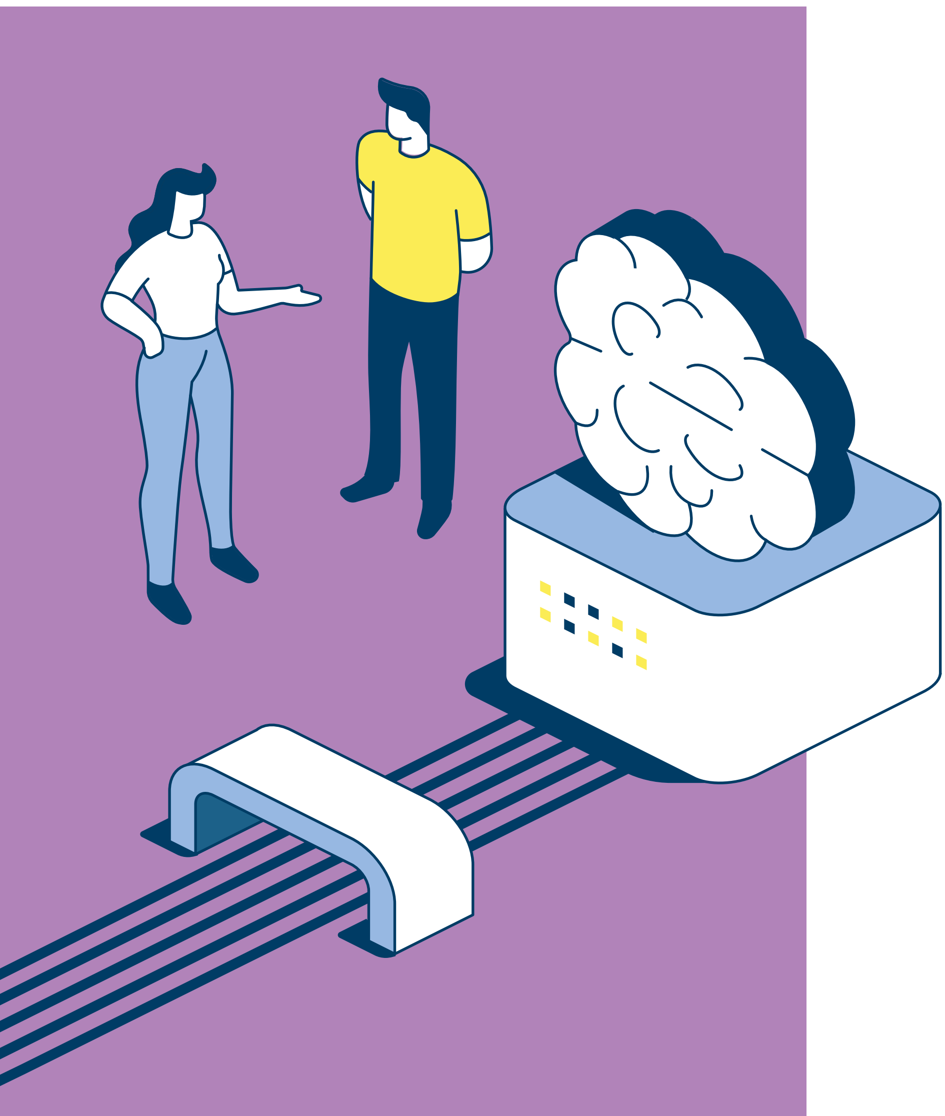
← Chelsea Maria John requires the computing power of JUPITER to develop open-source language models.

“Another challenge will be to minimize energy consumption. Training language models involves a very high level of electricity consumption.” This is another reason why JUPITER was designed to be particularly energy efficient (see infobox).

Energy efficiency

JEDI, the first module of JUPITER to be completed, ranks first on the Green500 list of the most energy-efficient supercomputers. It is capable of 72 billion floating-point operations per second per watt. The previous record was around 65 billion floating-point operations per second per watt. The highly efficient Nvidia superchips play a significant role in this achievement. But the use of green energy and warm water cooling also make a long-term contribution. This type of cooling consumes less energy than conventional air cooling. The waste heat is decoupled for further use, for example for heating on the Jülich premises.

Brain cells simulated in the electronic brain



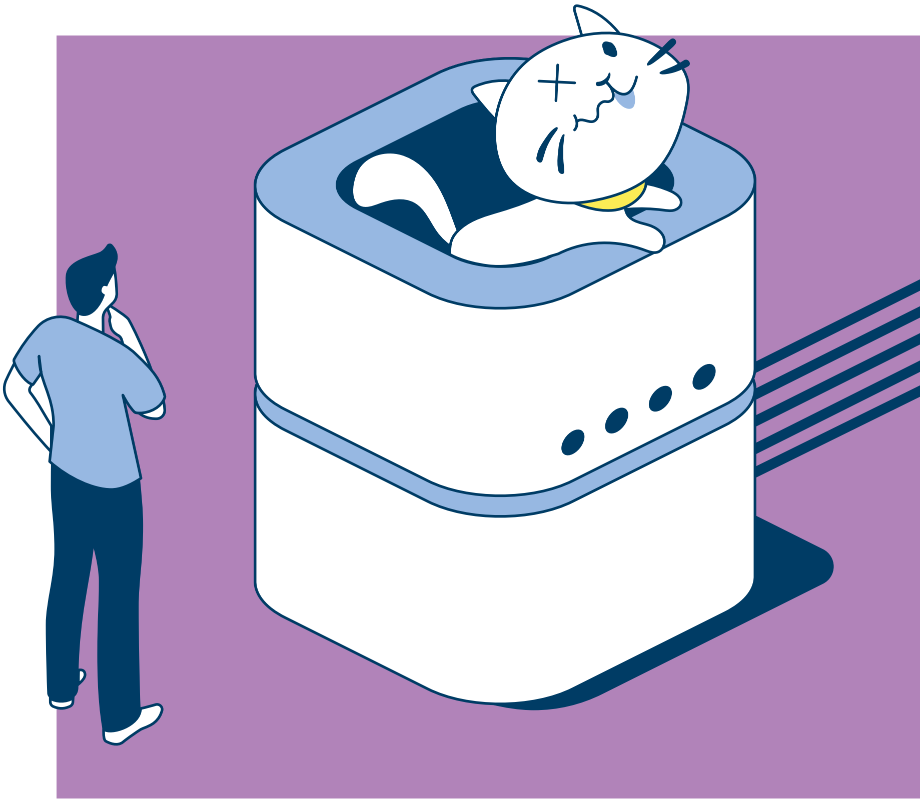
Large language models (LLMs) work with artificial neural networks inspired by the way the brain works. Dr. Thorsten Hater (JSC) is focused on the nature-inspired models of LLMs: neurons that communicate with each other in the human brain. He wants to use the exascale computer JUPITER to perform even more realistic simulations of the behaviour of individual neurons. Many models treat a neuron merely as a point that is connected to other points. The spikes, or electrical signals, travel along these connections. “Of course, this is overly simplified,” says Hater. “In our model, the neurons have a spatial extension, as they do in reality. This allows us to describe many processes in detail on the molecular level. We can calculate the electric field across the entire cell. And we can thus show how signal transmission varies right down to the individual neuron. This gives us a much more realistic picture of these processes.”

For the simulations, Hater uses a program called Arbor. This allows more than two million individual cells to be interconnected computationally. Such models of natural neural networks are useful, for example, in the development of drugs to combat neurodegenerative diseases like Alzheimer’s. The physicist and software developer would like to simulate and study the changes that take place in the neurons in the brain on the exascale computer.

Completely different changes control processes of learning and forgetting. Hater would also like to gain a better understanding of these processes through simulations: “The fascinating thing about our brain is that it is not a static structure. The idea that we can simulate it as a network with fixed connections is therefore wrong. Our brain is plastic, which means it changes within minutes, hours, or even days, for example by strengthening or weakening the connections between neurons. And it is precisely these processes that we want to simulate on the supercomputer in future.”

← Thorsten Hater wants to use the exascale computer to simulate processes in the human brain more realistically.

The Arbor simulation software has already been adapted to the hardware of the JUPITER Booster module. The Nvidia GH200 superchips are a combination of CPU and GPU, a system on a chip. In this form, the two processor types work together particularly efficiently because they are also closely coupled to each other spatially. This results in a high bandwidth and, therefore, a fast data flow



Quantum computer simulated on a supercomputer

For Dr. Dennis Willsch (JSC), the type of processors used for JUPITER calculations is of secondary importance: “Our simulations can run on any computer that has a Fortran compiler installed – even on a standard laptop.”

Nevertheless, the physicist typically uses high-performance computers to run JUQCS. This is software that can be used to simulate universal quantum computers. These machines use the exotic rules of the quantum world to solve specific tasks faster than a supercomputer – at least in theory. For example, the Shor algorithm, which can be used to crack certain encryption systems, should be calculated in no time at all by a quantum computer.

JUPITER

The exascale computer JUPITER (pictured in the photo-rendered image above) was procured by the European supercomputing initiative EuroHPC Joint Undertaking (EuroHPC JU), which is providing € 250 million in funding for the supercomputer. The German Federal Ministry of Education and Research (BMBF) and the Ministry of Culture and Science of the State of North Rhine-Westphalia are each contributing a further € 125 million in funding. JUPITER is being installed by the German–French consortium ParTec-Eviden. The data centre that houses JUPITER consists of around 50 container modules and covers more than 2,300 square metres, which is roughly the equivalent of half a football pitch.

In practice, however, there is no machine yet that has enough qubits for this task. A qubit is to a quantum computer what a bit is to a conventional computer.

Another problem is that “in the existing prototypes of quantum computers, many errors occur in the qubits. We therefore simulate these quantum computers under ideal conditions on normal computer systems. This shows us what the result should look like in theory, and we can use it to assess the quality of the real result,” says the physicist. However, there is a limiting factor in the simulation – the memory of the computer on which the simulation is run. “The memory is the real sticking point,” says Willsch. “And the memory requirement grows exponentially – it doubles for each additional qubit.”

A laptop can handle about 32 qubits with its memory. The record on a supercomputer is 48 qubits. JUPITER has enough memory to add a few more qubits to the simulation, says the researcher. “On an exascale computer, we could surpass the threshold of 50 qubits. That would be a new world record.”

← Dennis Willsch will use the supercomputer to investigate the world of quanta and simulate universal quantum computers.

The Nvidia GH200 superchip combines fast memory on the GPU side with energy-efficient main memory on the CPU side. Thanks to the integrated architecture, it is possible to use both memory areas homogeneously. The Booster module is therefore able to provide over 5 petabytes of memory that can be used by applications. This is equivalent to almost 650,000 standard laptops.

Hydrogen turbines and wind farms

The applications on which Mathis Bode (JSC) works are much more commonplace. He investigates the flow phenomena of liquids and gases. “This includes the aerodynamics of cars and aeroplanes, for example, as well as the processes inside turbines and engines.”

Flow simulations also play an important role in many aspects of the energy transition: How can battery packs be cooled efficiently? How can air conditioning systems be designed to keep a building at a constant temperature in an economical way? What is the optimum design for the rotor blades of wind turbines to ensure that they harvest as much energy from the air as possible? Mathis Bode also sees potential for using hydrogen as a future energy source: “In a hydrogen economy, we will need hydrogen power plants in the near future. To develop these plants, it will be necessary to simulate the processes inside them, for example the turbines. JUPITER allows us for the first time to depict real, industrially relevant conditions on a supercomputer. It also delivers the simulation results in a much shorter time.”

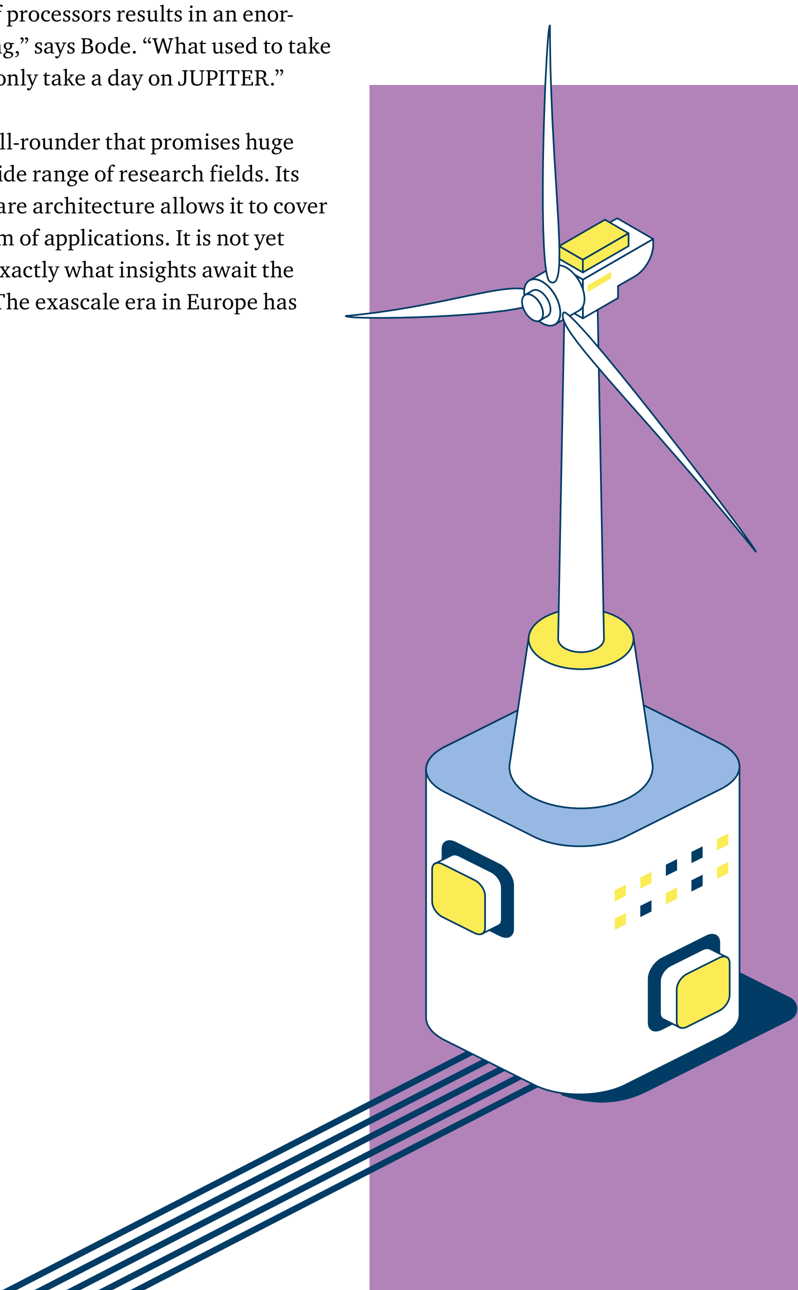
Flow phenomena are described by the Navier–Stokes equations. Solving these equations, however, is anything but routine. The differential equations are usually so complex that even supercomputers can only solve them approximately. Bode uses the nekRS software package for this purpose. In addition to pure fluid mechanics, the package can be used to take other processes into account, such as chemical processes that occur during combustion in an engine. “To do this, the program must consider the extreme conditions in the engine that influence the flow, such as high temperatures, high pressures, and strong turbulence,” explains the flow expert. nekRS can also simulate all relevant variables of flow phenomena simultaneously without cutting off any important information, for example the geometry-driven flow or the smallest turbulent vortices. “Taking all this data into account in the flow is a real challenge for a simulation and results in enormous computing and memory requirements.”

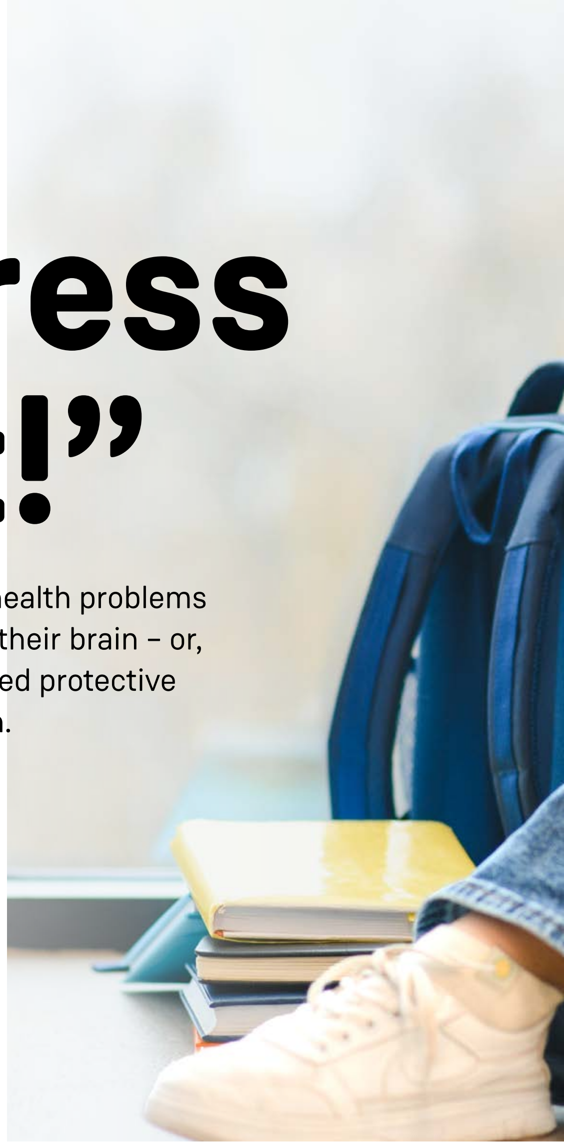
JUPITER is changing all that. “nekRS has already been optimized to work on graphics cards such as the ones used in JUPITER’s Booster module. The sheer number of processors results in an enormous time saving,” says Bode. “What used to take two weeks will only take a day on JUPITER.”

JUPITER is an all-rounder that promises huge advances in a wide range of research fields. Its modular hardware architecture allows it to cover a broad spectrum of applications. It is not yet possible to say exactly what insights await the Jülich experts. The exascale era in Europe has only just begun.

ARNDT REUNING

← Mathis Bode can calculate complex flow phenomena faster and more accurately with JUPITER. This is relevant for many areas of energy supply.





“Don’t stress me out!”

The way in which young people deal with mental health problems depends, among other things, on the structure of their brain – or, to be precise, on the presence of a well-developed protective layer for neurons, the myelin sheath.

Whether it be bullying at school, constant conflict at home, or traumatic experiences, some young people are able to cope well with such stresses, while for others they cause enormous problems. Such experiences can even lead to the development of mental illnesses. But what is the reason for the different responses to these experiences?

One assumption is that there could be a connection between brain structure and the resilience of teenagers – in other words their ability to deal with stressful situations. Sofie Valk and Meike Hettwer from the Jülich Institute of Neuroscience and Medicine (INM-7) and the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig have been investigating this matter together.

“We were particularly interested in changes in mental health in response to current stressor levels or traumatic experiences – such as the death of a grandmother, and how this in turn relates to the brain structure of adolescents,” explains Valk.

Behind this is the fact that the brain is heavily remodelled during adolescence. In particular, the cognitive networks are restructured and formed. Thinking becomes more complex, and the ability to fit into a social environment improves. However, these changes are usually accompanied by an increase in vulnerability. As a result, adolescents might become more unstable and susceptible to negative environmental influences.

For their research, the scientists used a publicly available data set from Cambridge and London. The data set includes the results of two surveys (conducted at intervals of one to two years) of 14- to 24-year-olds regarding their situation at home, their circle of friends, and the traumas they have experienced so far. The data also include two magnetic resonance imaging (MRI) scans of the brain for each subject, taken at the time of the surveys.

> **“With better myelination, the better you are able to deal with stress.”**
>
> SOFIE VALK

BRAIN SCANS ANALYSED

“While some young people reported feeling well despite difficult circumstances, others spoke of great stress caused by external factors,” reports Valk. To find out how the mental health of the test subjects is linked to the brain, the researchers analysed part of the data set in more detail. They analysed the MRI scans of 141 subjects who were able to cope better or worse with psychosocial stress over time, i.e. those who became more resilient or more vulnerable with age.

The researchers took a closer look at a specific part of the brain: the myelin sheath. Myelin consists of proteins and fats and forms a protective layer around the extensions of neurons. It stabilizes and insulates the network connections, ensuring that nerve signals can travel freely, quickly, and efficiently from cell to cell.

UNRESOLVED QUESTIONS

The extent to which the results might help to strengthen young people's resilience still needs to be investigated. "For us, it is an important finding that the different ways in which young people deal with stressful situations are also reflected in the development of their brains," says Valk. "It is possible that myelination and the stabilization of the networks in the brain can be improved by psychosocial support services such as talk therapy or sports programmes. This also needs to be investigated."

JANINE VAN ACKEREN

More and more young people affected

Depression, eating disorders, anxiety – such mental illnesses often first emerge during adolescence and young adulthood. The numbers are rising at an alarming rate: in 2022, almost one in five hospitalizations (19 %) of 10 to 17-year-olds was due to mental illness, compared to only 13 % in 2012. Most often, the young people were treated for depression.

During adolescence, the myelin sheath is still being developed. The researchers discovered an interesting connection between MRI proxies of myelin content and the ability to adapt to difficult circumstances. Adolescents who were able to cope better with difficult circumstances over time showed stronger myelination in certain brain regions. "There is clearly a connection between resilience and myelin development," says Valk. "The resilience and ability of adolescents to adapt to psychosocial stressors appears to have a direct influence on brain development. And the reverse is also true: with better myelination, the better you are able to deal with stress."

In addition to the myelin sheath, the scientists also used the MRI data to study the functional networks in the brain, specifically which brain structures and regions were closely interlinked when the subjects were at rest in the MRI scanner. The results revealed that adolescents who became more resilient over time not only showed stronger regional myelination, but that the cognitive networks in these areas also remained more stable. This means that the connections between the brain regions changed only slightly.

By contrast, the networks in adolescents who became more susceptible to stress over time and showed weaker myelination were less stable and changed more. In other words, this could mean that their brains were more vulnerable to negative external influences and that the adolescents were not as resilient.

↑ Dr. Sofie Valk is the head of research groups in Jülich and Leipzig

↑ Meike Hettwer is a doctoral researcher at the Max Planck School of Cognition.

Energy for the brain

Creatine appears to make tired people more awake – at least in the short term. This is the finding of a study on the effects of sleep deprivation on the brain.

When concentration wanes during the day, a coffee helps many people. But the popular caffeinated hot drink could now face competition. A study on sleep deprivation shows that the metabolic product creatine (see infobox) can give the brain a short-term energy boost.

For the study, a team of scientists led by Dr. Ali Gordjinejad from the Institute of Neuroscience and Medicine (INM-2) kept 15 subjects awake overnight and had them perform cognitive tasks during that time. At the beginning of the experiment, everyone received a high single dose of creatine. "Sleep deprivation can have an adverse effect on concentration, attention, and memory. Creatine improved the cognitive performance of all subjects, particularly processing capacity and short-term memory," says Gordjinejad.

Brain cells can normally only absorb creatine to a limited extent. However, sleep deprivation causes metabolic changes in the brain that promote absorption.

CREATINE

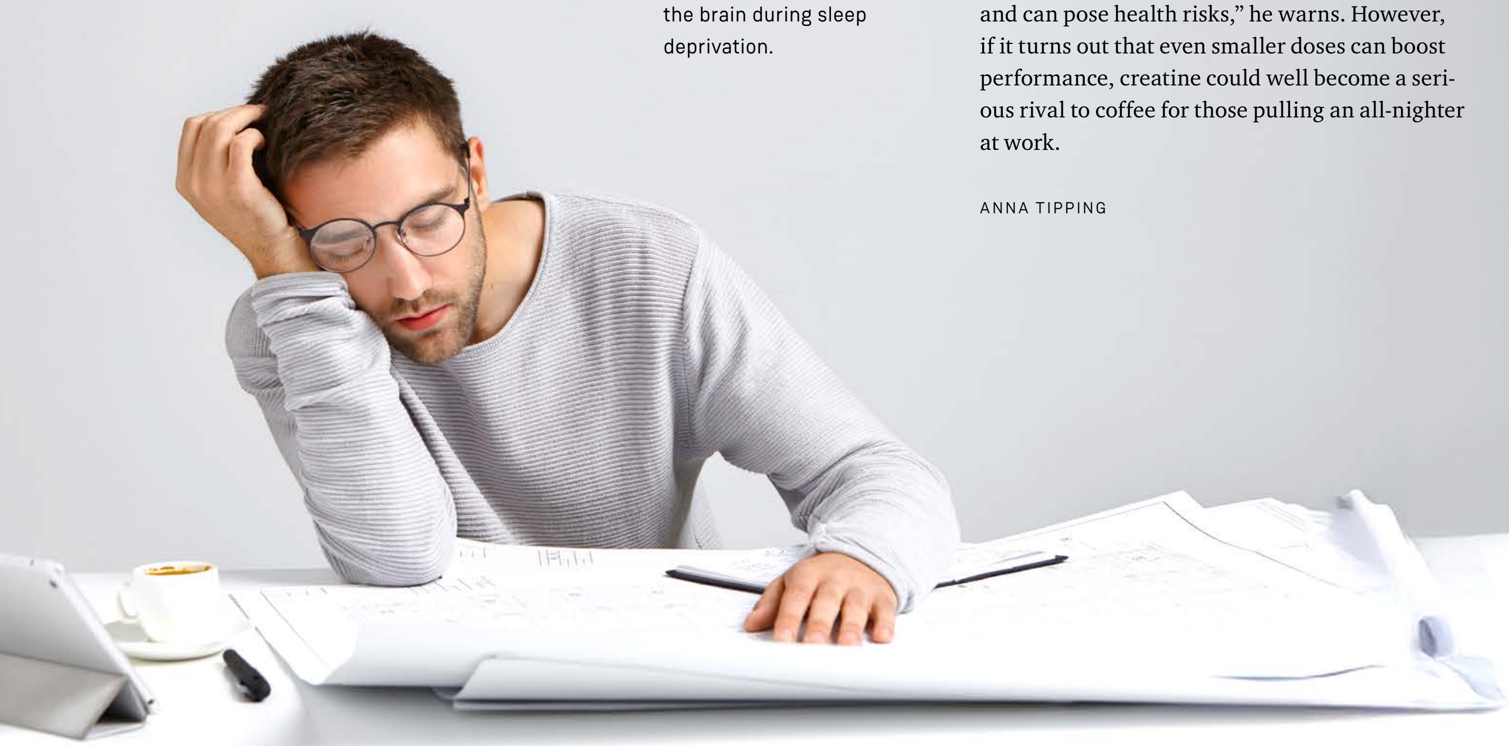
… is a carbon–nitrogen compound that our body produces itself. However, we also absorb creatine through our diet, especially meat and fish. It helps to supply the muscles with energy. In some sports, creatine supplements are very popular, since additional creatine can improve muscle build-up and performance under certain conditions. In medicine, it is used to treat patients with muscular atrophy, an impaired heart muscle function, or after heart attacks.

↑ Ali Gordjinejad investigated how creatine affects the brain during sleep deprivation.

"Creatine was thus able to alter the brain's energy reserves and improve brain performance," explains the researcher. The positive effect on the brain metabolism kicked in three hours after ingestion, reached its peak after four hours, and lasted up to nine hours.

"Various studies had already reported improvements in cognitive performance after a long creatine diet. We have now succeeded in demonstrating a short-term effect for the first time," underlines Gordjinejad. However, he strongly advises against now using creatine as a pick-me-up. "High doses put a heavy strain on the kidneys and can pose health risks," he warns. However, if it turns out that even smaller doses can boost performance, creatine could well become a serious rival to coffee for those pulling an all-nighter at work.

ANNA TIPPING



↑

What are you currently researching, Ms Geck?

Prof. Dr.-Ing. Lotte Geck, head of System Modelling at the Central Institute of Engineering, Electronics and Analytics (ZEA-2) and Junior Professor of System Engineering for Quantum Computing at RWTH Aachen University

"I'm looking for solutions to cope with extreme cold – for electronic circuits. They will control the computing units of quantum computers, the qubits. Qubits often only function faultlessly at temperatures close to absolute zero: at -273 degrees Celsius. Standard electronics are not designed for this. They can even disturb the qubits through the heat they generate. We use simulations to develop circuits that are not only suitable for a few qubits, but also for future computers with millions of qubits."

Capturing CO_2

To limit global warming, we need to emit less carbon dioxide in future and also remove large amounts of CO_2 from the atmosphere. This is the only way to prevent temperatures from rising by more than two degrees Celsius. Researchers involved in the DACStorE project are working on a technology to help achieve this aim.

How it works

The Mammoth DACS plant in Iceland works according to the adsorption process: fans direct ambient air into a special module, the collector, where the CO_2 chemically binds to a solid filter material. As soon as the filter can no longer absorb any more CO_2, the module is closed and the filter is heated to around 100 °C. This releases the CO_2 from the filter. The CO_2 is collected and the filter can be reused. Other DACS processes use liquids to capture CO_2 or use electricity instead of heat to remove the gas from the filter.

In May 2024, a Swiss company's plant called "Mammoth" was put into operation in Iceland. It is designed to pull 36,000 tonnes of carbon from the atmosphere annually, which is then permanently stored underground. It is the largest of around 20 direct air capture and storage (DACS) plants worldwide to date.

As a greenhouse gas, CO_2 is a major cause of climate change. Removing it from the atmosphere and storing it underground at first seems to be a simple solution to climate change. "But this is an unrealistic assessment," says Jülich scientist Dr. Freia Harzendorf from the Institute of Climate and Energy Systems (ICE-2): "DACS technology is not a solution that allows us to continue as before without needing to undergo an energy transition and change our way of life." She cites three reasons for this: Firstly, DACS systems require a lot of energy. If they use energy from fossil sources instead of renewables, then this does not help to protect the climate – quite the opposite in fact. Secondly, the systems are very expensive, as is their operation. It is usually cheaper and more sensible to avoid CO_2 emissions into the atmosphere in the first place. Thirdly, it is uncertain whether there is sufficient suitable storage space for enormous quantities of CO_2.

A NECESSARY MEASURE

Despite these limitations, DACS systems are an important component in the fight against climate change. According to the Intergovernmental Panel on Climate Change (IPCC), without the removal of CO_2 from the atmosphere, it will not be possible to limit the human-induced global temperature increase to below 2 degrees Celsius above pre-industrial levels in the medium term.

In the Paris Agreement, most countries made a commitment to limiting global warming to 1.5 degrees Celsius. Germany wants to help ensure this goal is reached through its Federal Climate Change Act, which outlines an aim to achieve greenhouse gas neutrality by 2045. Germany would then no longer contribute to an increase in the concentration of greenhouse gases in the atmosphere. This goal can be achieved in two ways: Either no more greenhouse gases are emitted at all, or emissions that are difficult to avoid are offset by measures that remove greenhouse gases from the atmosphere, i.e. through what are referred to as "negative emissions".

A view of the Mammoth plant from above. It is situated near a geothermal power plant that supplies the energy required for the process. →

← Freia Harzendorf is the scientific director of the interdisciplinary research project DACStorE, which is investigating the expansion of DACS technology.

EXPLORING DIFFERENT APPROACHES

CO_2 emissions that have been particularly difficult to avoid so far are those in some areas of agriculture as well as in the ceramics, chemicals, and glass industries. "Our analyses have shown that DACS processes offer a way of offsetting such CO_2 emissions from as early as 2035," says Harzendorf. Jülich system research studies have shown that in Germany, around 57 million tonnes of CO_2 will have to be removed from the atmosphere and stored in order to achieve greenhouse gas neutrality by 2045. According to the Jülich calculations, the capture costs for each tonne of CO_2 using the DACS process, which is used, for example, by the Mammoth plant in Iceland, will average € 290 per tonne of gas in Germany. "Nevertheless, DACS processes are a promising option," Harzendorf is convinced.

However, to extract the calculated amount from the atmosphere by 2045, this would require more than 1,500 plants with the same capacity as the Mammoth plant. In the DACStorE project, Forschungszentrum Jülich, five other Helmholtz centres, and TU Berlin are therefore working on a rapid, ecologically and economically sustainable ramp-up of DACS technology. Freia Harzendorf is the scientific director of the project. The aim of the DACStorE project is to further develop the technology and explore various approaches to reducing energy consumption and costs. In addition, the scientists are also analysing social acceptance levels and drafting recommendations for legal regulations and political measures.

At Jülich, the researchers are currently identifying the best DACS locations worldwide and designing systems that are optimized for the respective conditions. Harzendorf's team takes into account the most efficient and reliable supply of renewable energy, the availability of storage sites, and the transport routes to them. "Regional differences in temperature and humidity also play a role," says Harzendorf. Initial analyses already show that the energy requirements of DACS plants in different German regions differ by up to 15 % due to the respective weather conditions alone.

FRANK FRICK

← The collectors, which filter the CO_2 from the air, are housed in large containers in the Mammoth plant. When fully operational, there will be 72 containers.

On-chip energy harvesting

Electronic devices emit energy in the form of heat. Converting this waste heat back into electricity is only possible with special materials. A new alloy could make it possible to do this directly on microchips.

In Europe alone, around 1.2 exajoules of energy are lost every year through unused waste heat from electronic devices. This roughly corresponds to the primary energy consumption of Austria or Romania. However, materials that can convert heat into electrical energy are rare – and none of these thermoelectrics are compatible with current semiconductor manufacturing technology. This could be about to change. Five partners from Germany, Italy, and England have created a promising alloy out of germanium and tin that is also suitable for chip production. The alloy could be integrated directly into silicon-based microchips during production and convert the waste heat from computer processors into electricity.

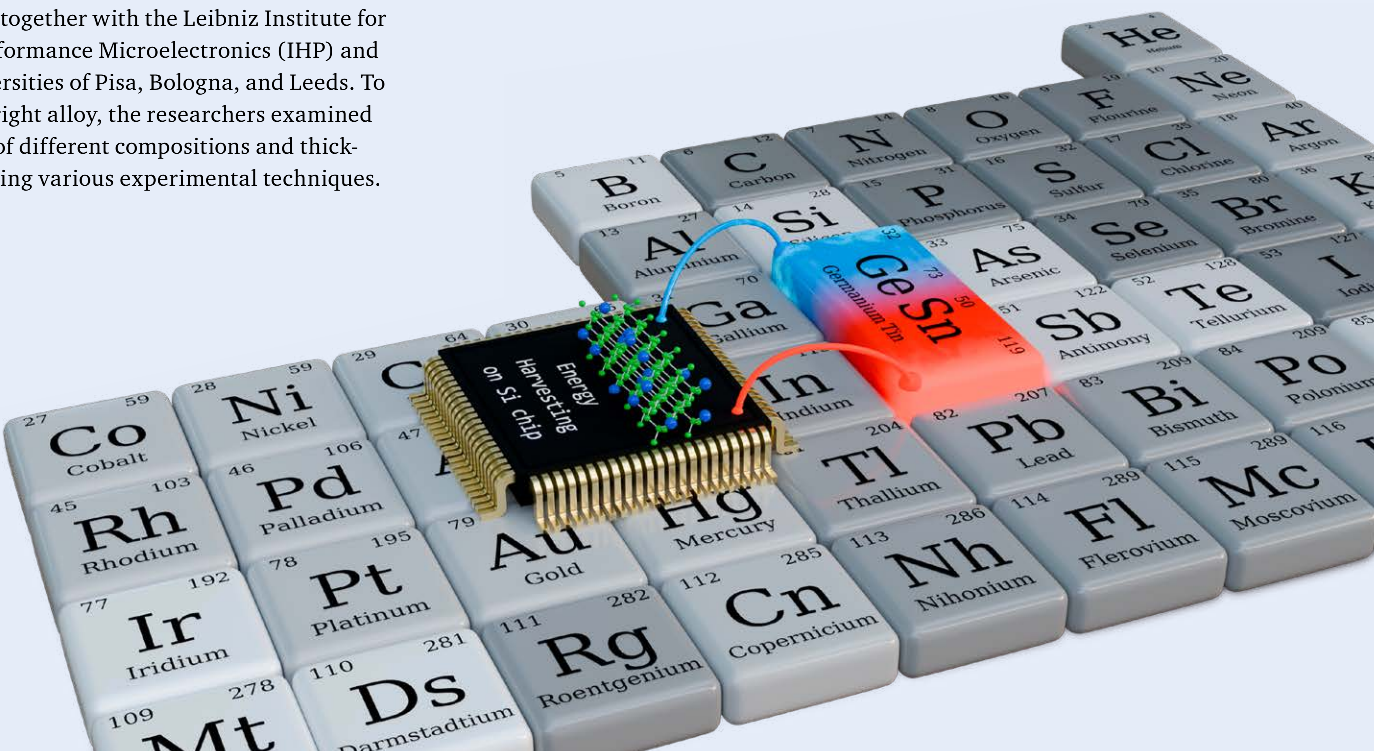
“Adding tin to germanium significantly reduces thermal conductivity while maintaining electrical properties – an ideal combination for thermoelectric applications,” explains Dr. Dan Buca, research group leader at Jülich’s Peter Grünberg Institute (PGI-9), which developed the alloy together with the Leibniz Institute for High Performance Microelectronics (IHP) and the universities of Pisa, Bologna, and Leeds. To find the right alloy, the researchers examined samples of different compositions and thicknesses using various experimental techniques. Using waste heat could significantly reduce the power and external cooling requirements of processors, thus increasing the efficiency of electronic devices. The joint research undertaking could therefore have a significant impact on the field of green IT infrastructures, according to Prof. Giovanni Capellini, project manager at IHP.

ADDING FURTHER ELEMENTS

Jülich and IHP now want to further develop the material and expand the germanium–tin alloy, first with silicon and then with carbon – all group IV elements of the periodic table, which form the basis of most electronic devices. The goal is to achieve a thermoelectric device that can demonstrate the potential of energy recovery through these group IV alloys.

TOBIAS SCHLÖSSER

↑ Dan Buca heads the research group dedicated to silicon-based epitaxy and photonics



A glimpse into the future

What will grow in our fields in future? Rising CO_2 levels and increasing extreme weather such as heavy rain, heatwaves, and droughts are changing the living conditions for wheat, barley, and other crops. Researchers want to ascertain how plants respond to climate change and determine how agriculture must adapt. AgraSim – a unique simulation facility for plants, soils, and climate – is helping them with this task.

1

Plant chambers

Six climate chambers (each roughly the size of a garage) contain ecosystems that are sealed off from the outside world. Important environmental conditions can be set as required. This means that long-term experiments can be used to simultaneously test how different climate scenarios and adaptation measures affect plants, soil, and the atmosphere. The researchers are studying existing crops as well as trialling new plant varieties.

What can be adjusted?

- Light (wavelength and intensity)
- Temperature of air and soil
- Humidity
- CO_2 levels
- Ozone levels

More information at go.fzj.de/effzett-agrasim_EN

Facts and figures

- Area: 18 x 11 metres over three floors
- Development and construction time: 9 years
- Funded as part of the Helmholtz Association's "Changing Earth – Sustaining our Future" programme and by the Federal Ministry of Education and Research

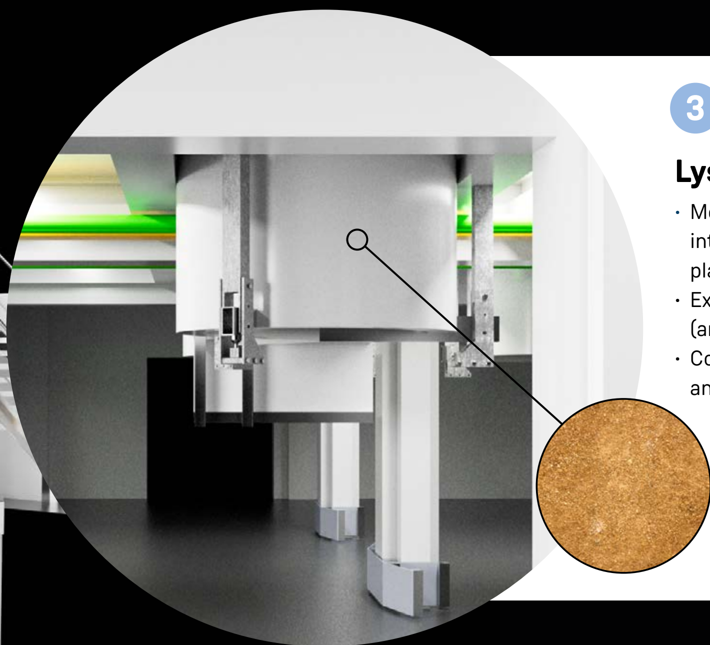
2

Analysis level

Real-time analysis of various data that can be used to record the exchange of substances such as CO_2 between soil, plants, and the atmosphere.

What can be measured?

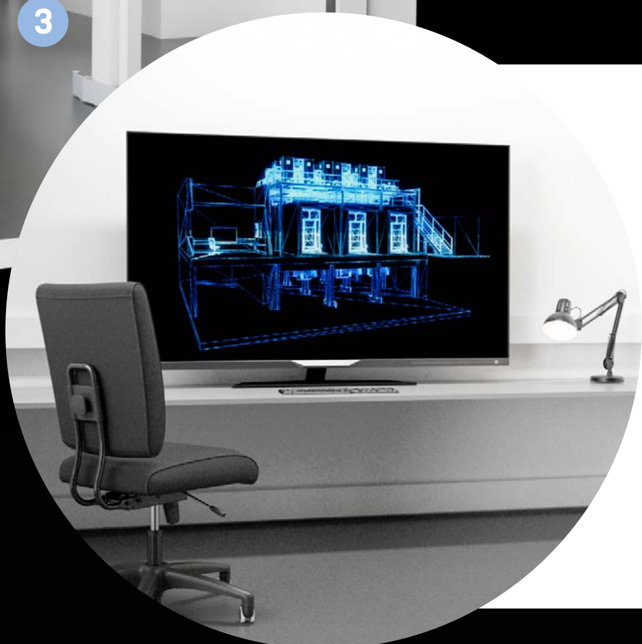
- Temperature of air and soil
- Humidity of the air
- Water content in the soil
- Various gases (CO_2, H_2O, N_2O, CH_4, NH_3, NO, NO_2)
- Gas and water isotopes (to trace the paths and processes of labelled substances)
- Leaf fluorescence (provides information on the photosynthetic activity of plants and their biostress)



3

Lysimeter

- Metal cylinder with 3 tonnes of intact soil for the plants in the plant chambers
- Extraction from real systems (arable soil)
- Complete control of temperature and soil humidity



4

Digital twin

A special feature of the chambers is that the entire facility will have a digital twin. This digital twin receives all the measured data required to trace the processes taking place in the climate chambers with the help of computer models. Conversely, changes predicted by the models can be experimentally tested in the chambers or experiments can be adapted using feedback from the models. The findings help to improve existing models and to develop new climate and agricultural models, for example with data for multiscale models. These multiscale models account for processes on different time scales and/or orders of magnitude – from molecules right up to entire fields.

The combination of experimental chambers of this size coupled with a digital twin is a unique feature of the facility.

How forests breathe

← Making the switch from USA to Forschungszentrum Jülich: Eva Pfannerstill

Heat, drought, and pests cause stress in plants. The composition of their "breath" is changing – which also has an impact on air quality and climate. Eva Pfannerstill is investigating these changes with a new measuring method.

The colourful screensaver on display in Dr. Eva Pfannerstill's office shows the famous "Mesa Arch" in Utah – a small reminder of her three years spent as a postdoc in Berkeley (USA). During her time there, she measured the air over Los Angeles before moving to Jülich's Institute of Climate and Energy Systems (ICE-3) as a young investigators group leader in October 2023.

In Germany, she now studies the air above forests instead of the air above cities. Her most important tool is a new measurement technique she developed at Berkeley. The combination of a state-of-the-art mass spectrometer and a special calculation method provides a wealth of measurement data on over 400 substances in the atmosphere. In addition to the typical plant substances, these include vehicle emissions, solvents, and cleaning and personal care products. "The great thing is that we are not only able to measure the substances, but also trace the sources from which they originate," says Pfannerstill. Ten measurement points per second can be recorded for the concentration of these substances, and the wind can be simultaneously analysed in three dimensions at the same frequency. “This allows us to quantify exactly which quantities of the measured substances are emitted at which location, for example whether they are blown in from the side or originate from the land surface,” explains the researcher.

IDENTIFYING THE CAUSE

Her method helped to determine why particulate matter and ozone pollution in Los Angeles increases with rising temperatures. “One of the causes is the temperature-dependent emissions that dominate the ‘breath’ of the metropolitan area,” says the expert. The main drivers of what occurs at high temperatures are terpenoids from plants, followed by evaporation from solvents. Both react with the nitrogen oxides from exhaust gases to form ozone and particulate matter (see infobox).

> **“With our method, we are not only able to measure the substances, but also trace the sources from which they originate.”**
>
> EVA PFANNERSTILL

In upcoming measurement campaigns, Eva Pfannerstill aims to find out how many terpenoids are emitted by German forests – this time not from an aircraft, but from a Zeppelin NT airship. This has both advantages and disadvantages: “We can fly much lower – down to 100 metres above the ground – but we have less space in the zeppelin’s cabin,” the researcher says. One challenge will be to adapt the spectrometer to the limited space available. “Here we can benefit from the experience gained from Jülich’s previous zeppelin campaigns and from the expertise of Jülich engineers,” stresses Pfannerstill, who is not the only Jülich scientist to collect data during measurement campaigns with the zeppelin.

Dr. Georgios Gkatzelis, for example, uses the same mass spectrometer to detect organic trace gases in the atmosphere of urban regions. Prof. Hendrik Fuchs and Dr. Anna Novelli, meanwhile, use an instrument to measure how reactive the detected gases are. And Prof. Uwe Rascher’s team is contributing an instrument that detects the fluorescence of plants. This indicates whether the plants are under stress before the human eye can detect any changes.

The researchers will also work together with local forestry authorities. “They can tell us, for example, whether the forests we fly over are suffering from a massive insect infestation. Plants emit different substances depending on whether they are suffering from drought or insect infestation,” says Pfannerstill.

The chemist has already conducted preliminary tests in the Jülich atmospheric simulation chamber SAPHIR and its coupled plant chamber facility SAPHIR-PLUS. During these tests, young beech and oak trees had to withstand temperatures of up to 40 °C and increased ozone levels: “That wasn’t good for the trees,” Pfannerstill summarizes. In addition, a controlled insect infestation is planned in the chamber.

FINDING THE PATTERN

“The SAPHIR-PLUS experiments show us whether there is a certain ‘response pattern’ of the trees to the different stimuli. We will be looking for these signals later during the zeppelin campaign,” she explains. The data from the campaign will be an important addition to existing climate models, since previous calculations of the stress response of forests are often solely based on laboratory measurements with a few small trees, Pfannerstill adds.

“That’s what makes Jülich research so special. We can collect data on a small scale in a controlled manner in the laboratory and then compare it with data from large-scale measurement campaigns in the real world. In doing so, we want to highlight ways in which the air quality in cities and the health of forests can be improved in a changing Earth system,” explains Pfannerstill.

BRIGITTE STAHL-BUSSE

Stress alters scents

Plants release gaseous scents into the air. The stress reactions triggered in plants by heat, drought, and pests alter the quantity and composition of the scents. These include volatile hydrocarbons and terpenoids such as isoprene. Exactly how this mix of molecules varies under different types of stress is the subject of intensive research. The quantity of the substances is important, as some of them react in the presence of nitrogen oxides from vehicle emissions or other emissions to form ozone and contribute to the formation of aerosols. Aerosols can have a cooling effect on the climate, but they can also turn into harmful particulate matter.

Time flies!

Seconds and minutes always tick along at the same speed on a clock. Nevertheless, our perception of how quickly time passes depends on the situation. With the help of AI, Jülich researchers have now found the first trace of a neural pattern in the brain that is responsible for how we experience time.

It can sometimes feel like time stands still – be it in the doctor's waiting room, during a menial task, or whenever a train is delayed. On other occasions, time passes by in a flash – during a summer holiday, while jogging through a forest, or having a fascinating conversation with a friend. Depending on the situation, people experience the passing of time differently. We have sensory organs for various senses such as hearing, feeling, or taste, but we do not have any for our sense of time. This means that something must be happening in our brains – but we're still unsure as to what exactly.

DO WE HAVE AN INTERNAL CLOCK?

Neuroscientist and psychiatrist Prof. Kai Vogeley and his colleague Dr. Mathis Jording have now found the first indication of a neural pattern for the perception of time. The Jülich researchers have been investigating how humans perceive time for years now. Do we have an internal sense of time and if so, how does it work? Is there some kind of time register for the mental clocks in our heads? And can our own experience of time be controlled or altered, for example, to improve our personal well-being?

Vogeley and Jording are interested in these questions from a basic research perspective. They also want to understand disturbances in the perception of time in the case of mental illnesses in order to develop new therapies. People suffering from depression, for instance, have an altered and often negative perception of time (see infobox). "They feel disconnected from the outside world because time passes more slowly and sluggishly for them. On occasion, time even seems to stand still, and in extreme cases it can feel like they are dead," reports Vogeley from his psychiatric practice.

"For people suffering from depression, time passes more slowly and sluggishly."

KAI VOGELEY

DEVELOPING A TIME LAB

But where does our sense of time come from? Our skin allows us to feel if something is hot or cold, while our noses can help us perceive smells as flowery or musty. "These are direct senses. I don't have to think about whether I've burned my finger. But when we experience time, we speculate afterwards and reconstruct from experiences how long something lasted, for example, by considering how often I looked at the clock while waiting," explains Jording. These are conscious cognitive processes. But Jording wants to know what happens in the situation directly while time is passing. Are certain neural processes taking place in the head? Is there any experience of time at all during the situation, a subjective feeling for time?

To answer these questions, scientists developed an innovative concept in the EU research project VIRTUALTIMES, which is coordinated by Jülich. At its core is a new "time lab" in which the perception of time can be studied detached – as far as possible – from external influences or distractions. These studies are enabled by highly realistic, AI-based virtual reality technology.

Perception of time in mental illness

People with depression often perceive time as slowing down. This can even go so far as a patient thinking they are dead because it feels like time is no longer passing for them. Some people with autism do not perceive time as flowing constantly, but rather in individual moments that string together like pearls. If this sequence is disrupted, for example if usual routines are interrupted, the perception of time also alters and the future then becomes less tangible. Some of those affected report that they no longer have a sense of time at all. Many people with schizophrenia can no longer reliably distinguish whether something is taking place in the past, present, or future. This can go so far that patients do not experience their present self as being the same person as in a previous moment.

> **“When we experience time, we later reconstruct how long something lasted from our experiences.”**
>
> MATHIS JORDING

When you enter the time lab, you see plain tables, dull walls, and an ordinary office chair. But as soon as you put on the VR headset, you find yourself in a virtual engine room made of steel in the middle of a spaceship. You can see through a window into space directly in front of you. Countless stars fly towards the test subjects. Their task is to report how fast or slow time seemed to them every 20 seconds. The researchers vary the number of stars and the speed at which they fly. “We therefore use simple visual stimuli to influence the experience of time in short intervals,” says Jording. At the same time, the researchers measure brain activity using an electroencephalogram (EEG). More than 200 people have taken part in various experiments in the starfield so far.

The researchers used some of the measurements to train a machine learning algorithm that was designed to detect a correlation between brain activity and the reported perception of time. The researchers then gave the AI the rest of the data and compared the AI’s prediction for the perception of time with the subjects’ statements. The AI was surprisingly accurate.

AI DETECTS A PATTERN

It seems that the algorithm had indeed detected a neural process, a pattern in the EEG measurements that enabled it to correctly predict the test subject’s perception of time. “For six months, we didn’t trust our own results,” says Jording. To increase the accuracy of the AI and to ensure that the predictions were not just a coincidence, the researchers conducted further studies – and their results were confirmed.

The researchers want to use the findings to develop a theory about the perception of time. They also want to investigate the role that the perception of time plays in human well-being and the connections between brain activity and the perception of time in mental illnesses. Ultimately, this might even lead to a therapy concept, a kind of time treatment. But it will take a long time before we get there, Vogeley suggests. However, he and Jording have established the basis for such a concept with their time lab and virtual starfield.

KATJA ENGEL

Into the tiny world of atoms

More precise than ever before – a new quantum sensor is able to measure magnetic fields with a spatial resolution of less than an atomic diameter. The tool is set to help with materials research and the development of quantum computers.

Quantum sensors can be used to precisely measure the smallest changes in physical quantities such as gravity or electric and magnetic fields – often more accurately than with conventional sensors. Quantum sensors use quantum mechanical effects such as the spin of an electron. However, up until now, they have always been limited. It was not possible to use quantum sensors to accurately measure physical quantities on the atomic scale. This was due to the size of the sensors.

"The world of atoms is tiny. Their diameter is typically 1 angstrom, which is about a million times smaller than that of a human hair. Quantum sensors had previously been too large and bulky to get close enough to individual atoms," says Dr. Taner Esat from the Peter Grünberg Institute (PGI-3).

MOLECULE AS A SENSOR

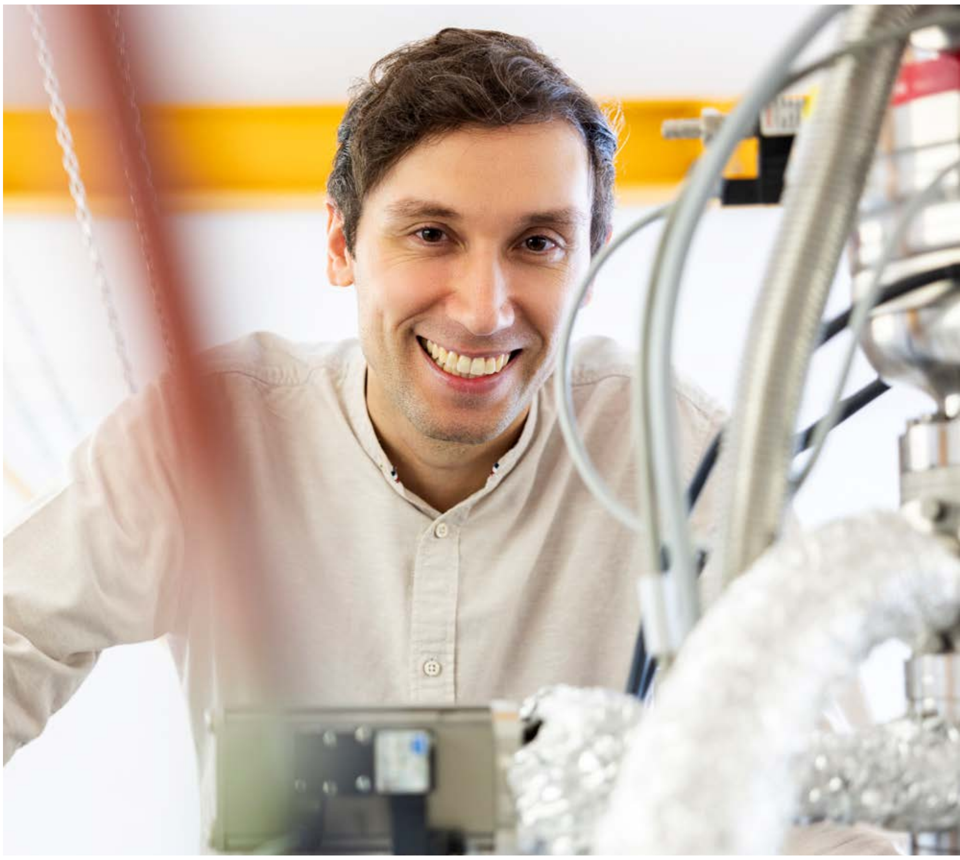
Together with Prof. Ruslan Temirov and Prof. Stefan Tautz from Jülich and colleagues from the IBS Center for Quantum Nanoscience (QNS) in South Korea, he has found a solution. The scientists positioned a molecule, in which an electron spin is trapped, at the tip of a scanning tunnelling microscope and successfully used it as a sensor.

"Our method makes it possible to bring the sensor to individual atoms within a distance of just a few atoms and to detect changes in magnetic fields with a spatial resolution of around one-tenth of an angstrom. The data provided by the sensor are as detailed as images from magnetic resonance imaging (MRI) scanners used in medicine to examine tissue and organs," says Esat.

The small, mobile sensor should help researchers to better investigate and understand materials, and thus develop new quantum materials and catalysts. It will also help in advancing the diagnosis and realization of innovative quantum computers. Esat will continue his experiments with the quantum sensors at Jülich.

He will be aided in his efforts by a Starting Grant from the European Research Council (ERC), which he received in September 2024. These grants are endowed with up to € 1.5 million.

TOBIAS SCHLÖSSER



↑ Milestone achieved: quantum physicist Taner Esat has been pursuing the idea of the molecular quantum sensor for several years.

Always thinking about recycling

Roll-up displays and photovoltaic films for façades – organic electronics have a great deal of potential. However, recycling concepts should be in place before the new technology becomes a mass product, recommends materials researcher Christoph Brabec.

Mr. Brabec, together with colleagues from Germany, the UK, and the USA, you have called for the sustainable development of organic electronics. Could you tell us a bit more about this?
The technology is being used in more and more products. Displays are currently the largest market – known as AMOLED or OLED for TVs and smartphones. And more applications are set to be added. To avoid producing unnecessary electronic waste in future, we need to design sustainable solutions today – for example for production and recycling. In 20 years' time, when a mass market may have developed, it will be too late.

What does organic electronics refer to exactly?
This is a collective term for electronic circuits consisting of organic polymers or smaller organic molecules. Above all, it refers to semiconductors, which are the central building blocks of all digital devices. Conventional variants are largely based on silicon, while the organic ones are mainly based on carbon.

What is the difference between silicon and carbon semiconductors?
In contrast to silicon, which is grown as a single crystal, the organic compounds are chemically synthesized. Organic electronics can be produced in a relatively energy-efficient manner in comparison and the process is well suited to producing large-format, thin electronic layers – such as flexible polymer films. Organic electronics also offer advantages for photovoltaics.

What are these advantages?
Organic semiconductors are very easy to make transparent. They then absorb infrared light, i.e. thermal radiation, but not visible light. Unlike conventional silicon semiconductors, they can still achieve high performance efficiency despite being so thin.

This makes them particularly suitable for integrated PV systems in façades, windows, or photovoltaics above agricultural land, for example. Another emerging market is devices connected to the Internet of Things, such as small electronic gadgets and sensors that can be operated without batteries.

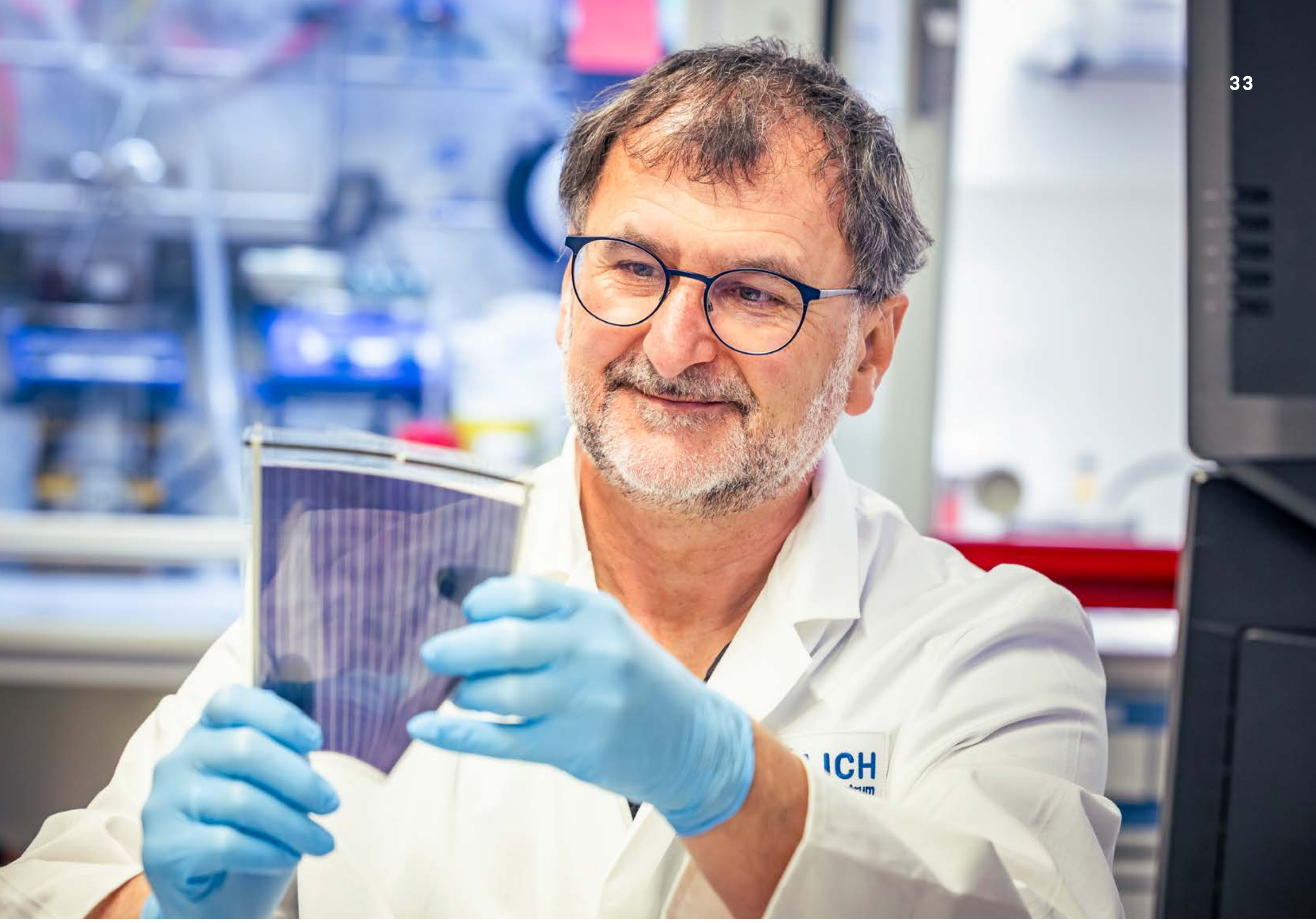
And what about the environmental impact?
If you look at the entire value chain for solar cells, organic-based semiconductors release two to three times less CO_2 than silicon-based ones. The production process involves low energy consumption and the low weight of the films makes the technology particularly suitable for transportation and assembly. You end up with significantly more watts per gram.

But organic electronics are still relatively expensive?
Yes, that's because there are millions of different organic semiconductors. In practice, no standard material has yet become established and no value chain has been consolidated. This makes production expensive. But we assume that this will change. It is therefore important to look at the entire life cycle of the components today in order to minimize the ecological footprint.

i

Printed solar cells that are environmentally friendly and flexible are also the focus of the Solar TAP innovation platform, which Christoph Brabec is helping to coordinate. Find out more here: go.fzj.de/endeavours-solartap_EN

You can find a longer version of the interview at: go.fzj.de/effzett-brabec-interview_EN



So what needs to be done?
Many electronic components are difficult to take apart again. Organic electronics should be designed so that they can be easily and economically recycled. The energy and costs involved in recycling must not be higher than for production. We have to take this into account right from the development stage. The goal is to establish a circular economy.

And how can that be achieved?
Through multi-layer designs, for instance, with components consisting of easily separable layers. It is thus possible to ensure that various materials can be easily recycled at the end of their product life. Organic semiconductors are very well suited for this because they can be easily dissolved again in contrast to silicon-based semiconductors. We should also use easily recyclable or easily degradable substrates and ensure that no toxic substances are used in production.

How is your research making a contribution?
At our institute, we are focused on manufacturing processes. We investigate the influence of production on the end result – in other words a finished organic semiconductor – and we also try to optimize the process so that the semiconductor delivers the best possible performance.

How do you go about this?
We build research and development facilities that are controlled by artificial intelligence. The AI helps us to find the "simplest" but most suitable materials and to optimize their manufacturing process – for example, materials for organic solar cells that are high-performance, long-lasting, and easy to recycle. We thus want to make renewable energy even more sustainable and more attractive in the future.

THE INTERVIEW WAS CONDUCTED BY JANOSCH DEEG.

Personal background

Prof. Christoph Brabec is a director at the Helmholtz Institute Erlangen-Nürnberg for Renewable Energy (IET-2), a branch office of Forschungszentrum Jülich. At IET-2, he heads the research department High-Throughput Methods in Photovoltaics. At the same time, he holds the Chair of Materials for Electronics and Energy Technology at Friedrich-Alexander Universität Erlangen-Nürnberg. The materials researcher regularly appears in the list of the world's most highly cited researchers.

KNOWING-IT-ALL

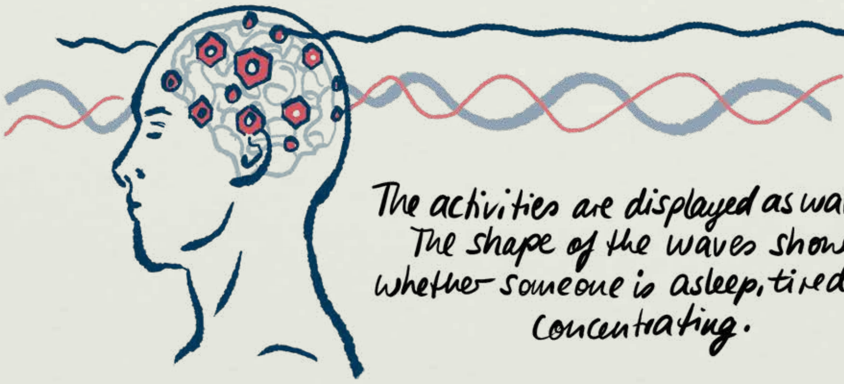
EEG

Electroencephalography, or EEG for short, records electrical currents in the brain. It is used to check brain activity for example in the event of suspected illness.

HOW DOES IT WORK?

Up to 64 electrodes are placed on the outside of the head according to a fixed pattern. They measure the sum of the activities of nerve cells in the individual brain regions.

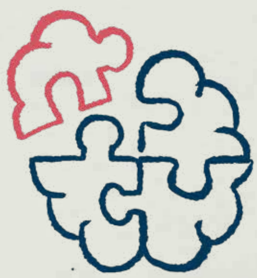
Nerve cells in the brain transmit information as small electrical impulses. Many impulses mean high activity.



The activities are displayed as waves. The shape of the waves shows whether someone is asleep, tired or concentrating.

WHAT DOES AN EEG HELP WITH?

Certain wave patterns can indicate illness or disorders, such as epilepsy or brain demage. An EEG can be used to study sleep, monitor anaesthesia, and determine brain death.



UNIQUE

Every person has a typical EEG pattern, which can differ significantly from that of others.

WHAT DOES JÜLICH DO?

Brain researchers use EEG in sleep research and to better understand neurological brain diseases. Often it is combined with other methods such as magnectic resonance imaging (MRI).

THUMBS UP

SCIENCE VIDEOS FROM AROUND THE WORLD

Creative and compact research

What can help sick plants? During which season do meteorites hit Earth particularly often? In the “Science in Shorts” videos, researchers from around the world share their knowledge with us. In just under a minute, they explain what they are working on. The topics are varied, the presentations are creative, and they often get to the heart of complex issues in an entertaining way. Out of a total of 250 short films, Springer Nature and Merck have honoured the best 10 with “Nature Awards”. The top ten and many more clever videos are available at:

– NATURE.COM/IMMERSIVE/SCIENCEINSHORTS/WATCH/INDEX.HTML –

EXPERT LECTURES ONLINE

Bringing science into your living room

Have you heard about supercomputers that can perform several billion floating-point operations in a matter of seconds? Or would you like to find out how hydrogen is set to help drive the energy transition? In the lecture series “Science online” at Forschungszentrum Jülich, experts provide answers to the exciting questions of our time. Every Thursday, they present their projects – live and streamed directly into your living room. Interested? Take part in a live event and join the discussion. Missed the event? No problem! Many of the lectures are also available as recordings.

– FZ-JUELICH.DE/EN/ABOUT-US/CONTACT-VISITOR-INFORMATION/VISIT-THE-RESEARCH-CENTRE/SCIENCE-ONLINE –

ASTRONOMY PHOTO COMPETITION

Radiant beauties

Northern lights that look like a dragon, unusual images of the surface of the sun, the glowing Milky Way in the night sky above the Namib Desert – many impressive photos have been entered in the Astronomy Photographer of the Year 2024 competition. Some of the images can be viewed on the home page of the Royal Museums Greenwich, which has launched the global competition for the 16th time. Those who like to travel can see even more of the extraordinary shots – the National Maritime Museum in London will be showcasing more than 100 of the submitted photos until summer 2025.

– RMG.CO.UK/WHATS-ON/ASTRONOMY-PHOTOGRAPHER-YEAR/GALLERIES/2024-SHORTLIST –

RESEARCH IN A TOOT

Congratulations, IAGOS! And thank you! For 30 years now, your measuring instruments in passenger aircraft have been providing climate data from the Earth's atmosphere.

IAGOS stands for In-service Aircraft for a Global Observing System. The European research infrastructure records various climate variables – from ozone and carbon compounds to water vapour, aerosols, and cloud particles. The data help to gain new insights into the climate – for example, how it changes over time. They also help to improve climate models and weather forecasts. More than 300 organizations use the data. IAGOS is coordinated by Jülich together with the French National Centre for Scientific Research (CNRS).

More about IAGOS and the creation of artificial ice clouds by aircraft in the *Forschungsquartett* podcast (in German):
https://detektor.fm/wissen/forschungsquartett-eiswolken