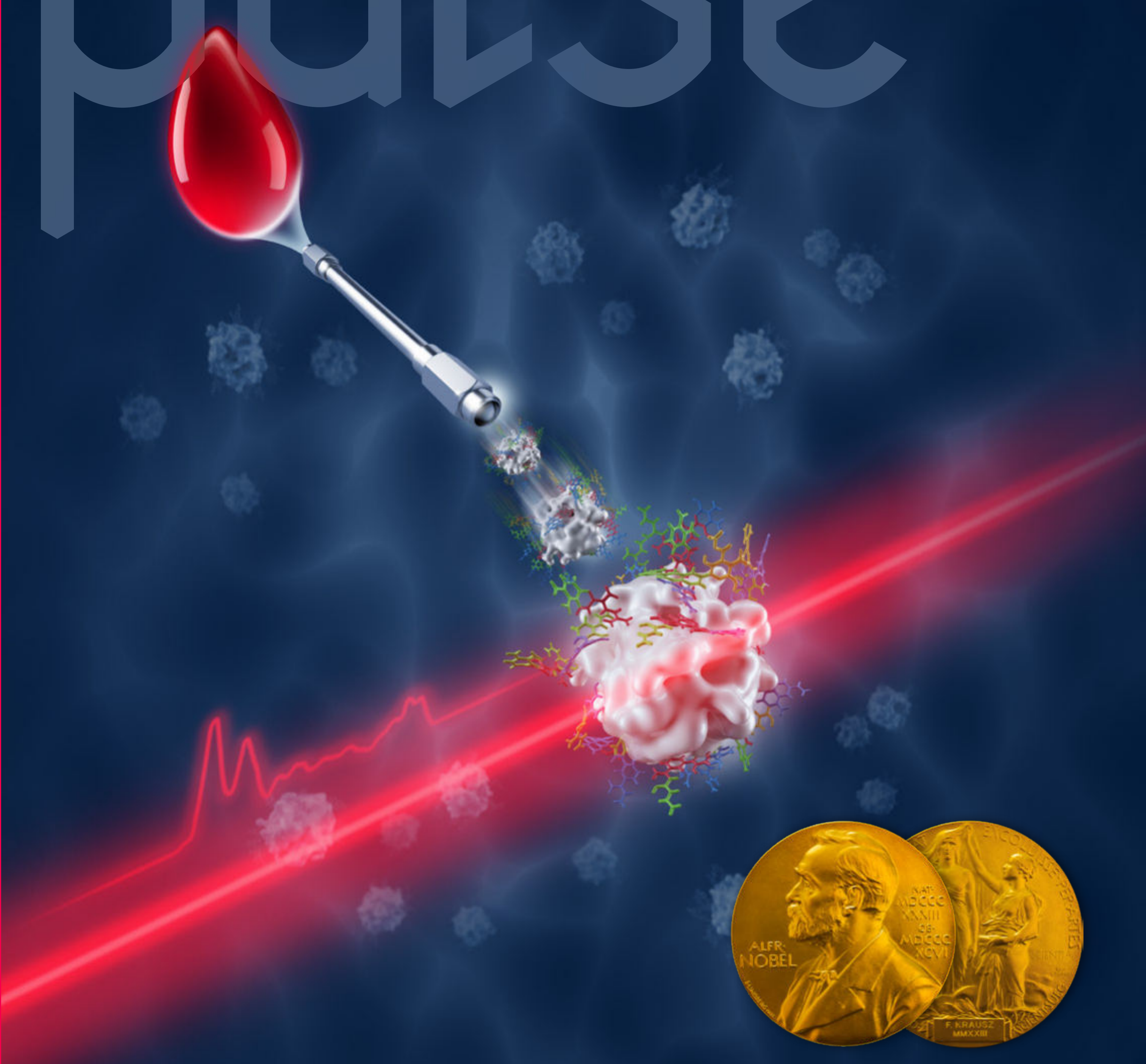
the newsletter of attoworld

volume 4 (2023/24)

pulse



Nobel Prize in Physics 2023

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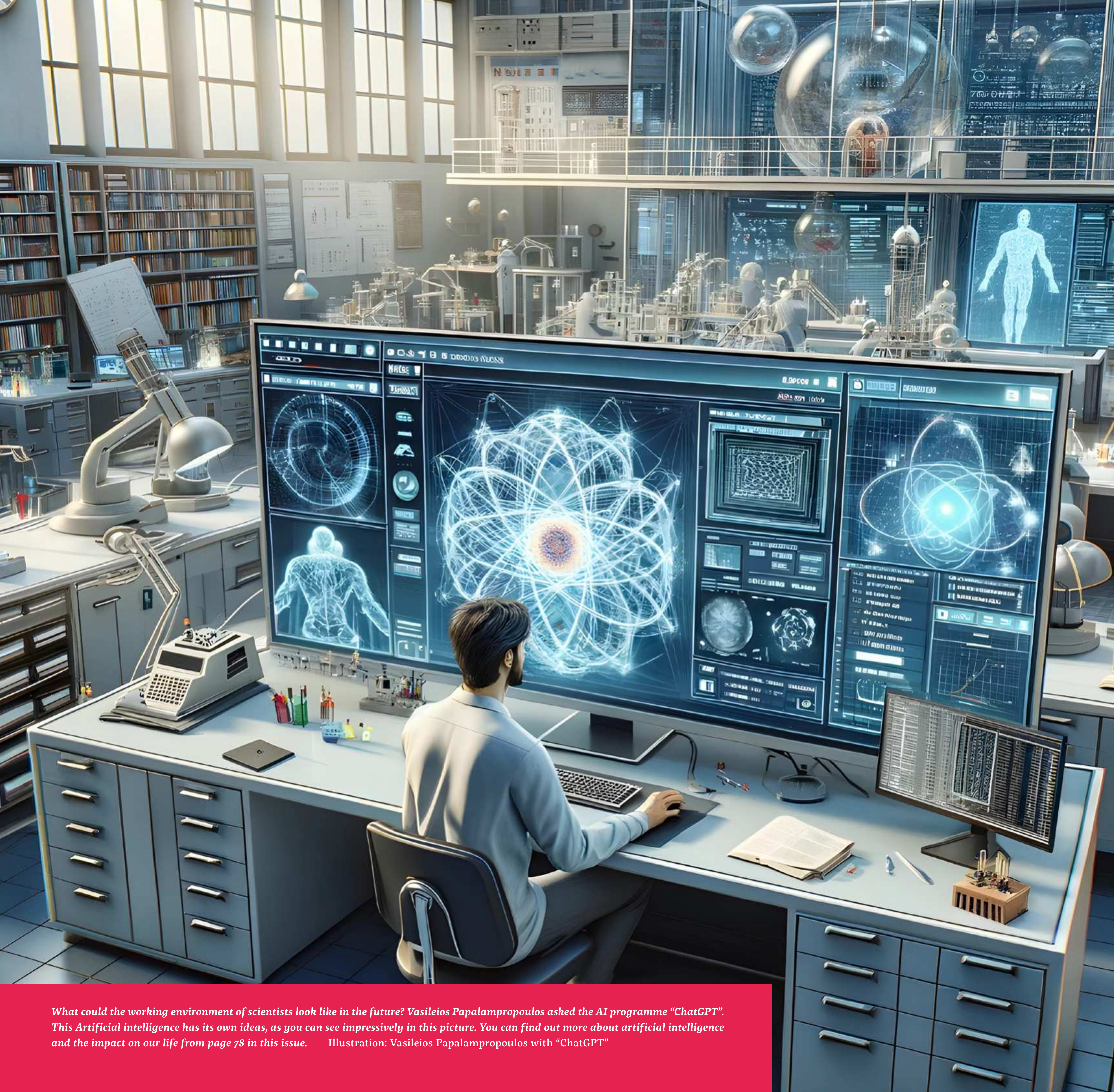
LMU



What could the working environment of scientists look like in the future? Vasileios Papalampropoulos asked the AI programme "ChatGPT". This Artificial intelligence has its own ideas, as you can see impressively in this picture. You can find out more about artificial intelligence and the impact on our life from page 78 in this issue. Illustration: Vasileios Papalampropoulos with "ChatGPT"

dear attoworldians!

You are currently reading the latest issue of our ATTOWORLD-magazine "pulse". I am particularly pleased that so many former members of the ATTOWORLD-team have contributed to this publication. Matthias Uiberacker, for example, looks back on the early days of attosecond physics when Ferenc Krausz and his group at the Vienna University of Technology generated the first attosecond flashes of light in 2001. Matthias was a young doctoral student at the time. This naturally gave him a very special perspective on the pioneering experiments of his long-established colleagues. It was an exciting time that laid the foundation for the prestigious Nobel Prize in Physics, which Ferenc Krausz received in 2023. Shawn Sederberg invites you to visit Canada and get an idea of his work there in a very personal article. And finally, Marcus Ossiander reports on his research into meta-optics.

Our magazine thrives on the diversity of expertise of the group members, who have once again gone to great lengths to contribute exciting articles in this issue. Artificial intelligence is covered as well as topics from the fields of medicine, optics and, of course, ultrafast physics. There is also a colorful potpourri of hopefully entertaining and exciting articles from the editors of the PR-team.

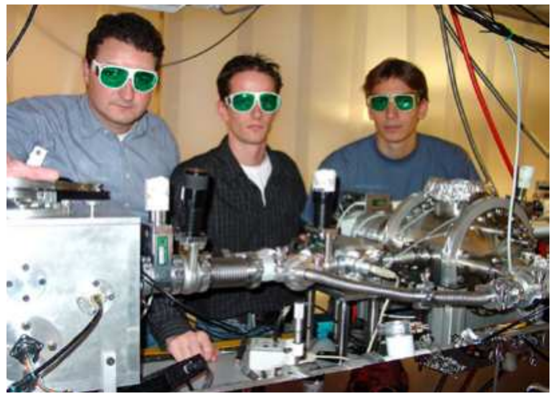
I wish you an entertaining read and hope you enjoy browsing through the new magazine.

[Thorsten Naeser]
Head of Public Relations

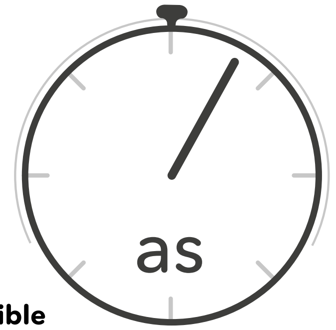
content

showroom

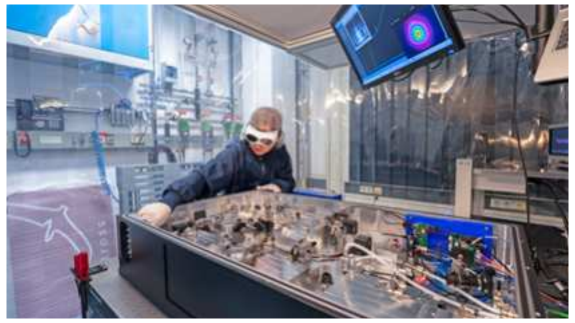
The war in Ukraine is still raging. Help on the ground is more important than ever. Our aid organisation Science4People (S4P) is active there. S4P is committed to promoting education and development opportunities for children and young people in war and crisis regions.



Matthias Uiberacker reports on the legendary events that took place on the very first attosecond beamline in 2001.



Our website www.attworld.de is the central communication tool of our group. Here we tell you a little bit about the history of the website and explain which programs are used to run it.



Last summer, PULSED employees had reason to celebrate. The company had its first anniversary and an exciting founding year behind it. Nathalie Lenke explains how the idea to launch PULSED came about and how the start-up company strives to develop devices for health monitoring and early disease detection.

Alexander Guggenmos slipped into the role of "Neo", the protagonist of the successful and legendary "The Matrix"-film series originally played by Keanu Reeves.

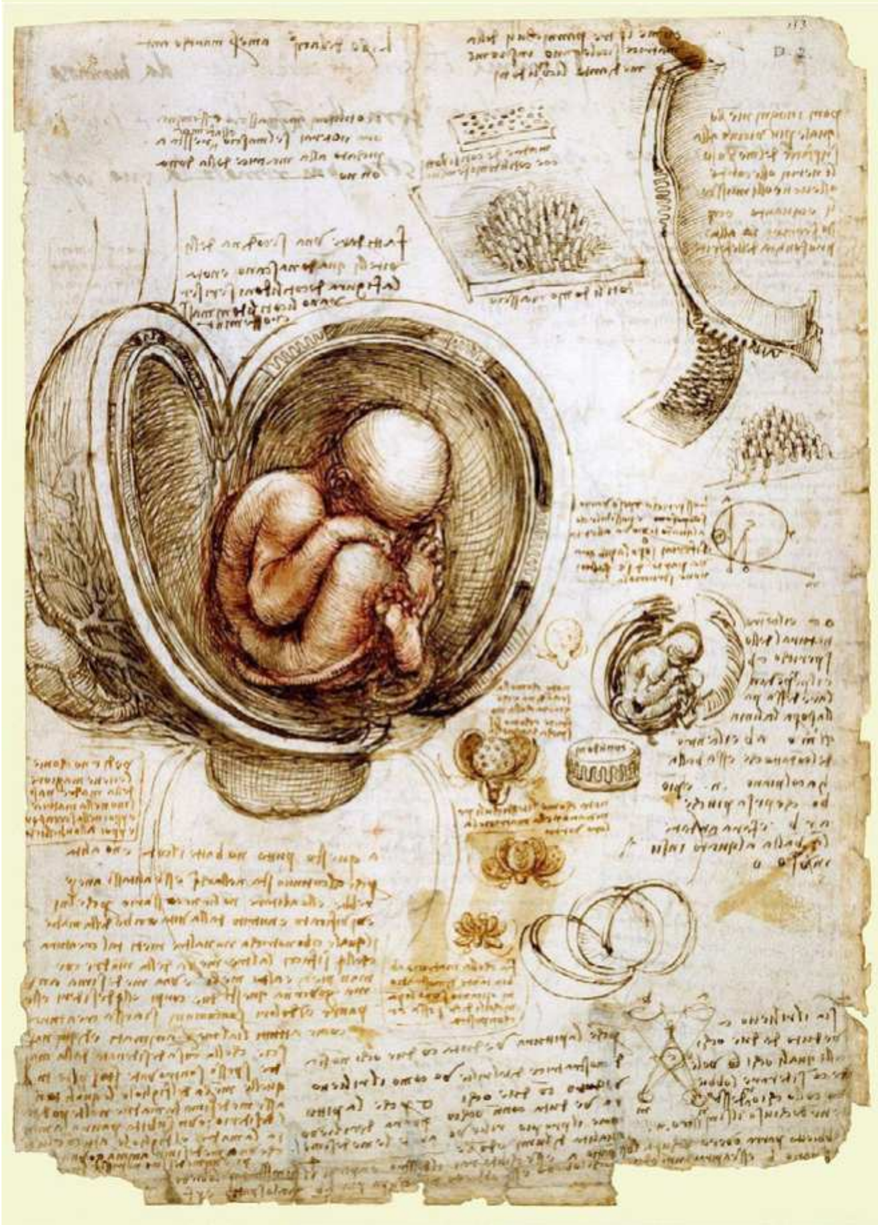
It is very well known that artificial intelligence (AI) is starting to become more relevant as time goes by, with its uses becoming more and more common in our everyday lives.

from ancient wisdom to modern technologies

january 22, 2024 // Dr. Mihaela Žigman

What is health? This foundational question has engaged philosophy and medicine throughout the course of history and across civilizations. It spans from the ancient holistic view of vital energies and the balance in bodily fluids to the Renaissance's revelations in anatomy. The subsequent era was dominated by a conceptual model that perceived the human body like a "clockwork mechanism" governed by physical laws. In principle, remnants of Descartes' reductionistic philosophy from 17th century left an imprint on medical practices up until today, such as symptomatic treatments and the replacement of body parts. And when considering a health state from a more holistic perspective, the reductionistic separation of body and mind still continues to be challenged. Additionally, the 19th century revolution enabled the capacity of seeing the body at cellular resolution, and currently, at molecular resolution. The concept of health of an individuum spans multiple levels, extending beyond health at population and societal levels.

Fast forward to the contemporary technological age, where modern molecular medical tests utilize only a drop of blood to validate how well certain organs and tissues function in our body. For instance, DNA from blood cells can inform on the presence of variants of a gene indicating a degree of inherited risk for some diseases. In other applications, wearables with sensors can measure certain circulating biomolecules providing insights into diseases like diabetes. These minimally- or non-invasive tests offer glimpses into our bodies' intricacies. Yet, in spite of the promise of innovation, we are far from understanding health, predominantly due to the limited number of meaningful biomarkers and the decades required to work out new strategies. We are especially far off, as we do not sufficiently well understand the mechanism of onset of most diseases, hindering our ability to comprehend the molecules necessary to depict the health of individual organs.



Looking inside the body, at its blueprint and how it works, has always fascinated scientists and artists alike. For a long time, it was a view of the hidden and mysterious that people wanted to understand better and better with increasing knowledge.

The fetus in the womb; sketches and notes on reproduction c.1511
Leonardo da Vinci (1452–1519) // Recto: Red chalk and traces of black chalk, pen and ink, wash // 30.4 × 22.0 cm (sheet of paper)
RCIN 919102 // The Royal Collection Trust

Understanding risks: In modern healthcare, we are getting better at figuring out who might be more at risk for certain health issues. It is like a heads-up, helping doctors tailor treatments and care plans for each person. With advanced tools, we hope to even predict possible health paths, letting us take steps to stay healthy or get ahead of potential problems, thus offering a proactive approach to healthcare.

Personalized treatments: In an idealistic healthcare scenario, modern companion diagnostics are like personalized guides, assisting doctors pick treatments that work best for each person based on their unique genetic and metabolic makeup, which is different between people of different origins and changes the risk for certain disease or response rates to certain drugs. Kind of a tailor-made plan, making sure the treatment fits just right and has the best chance to be effective for a given individuum.

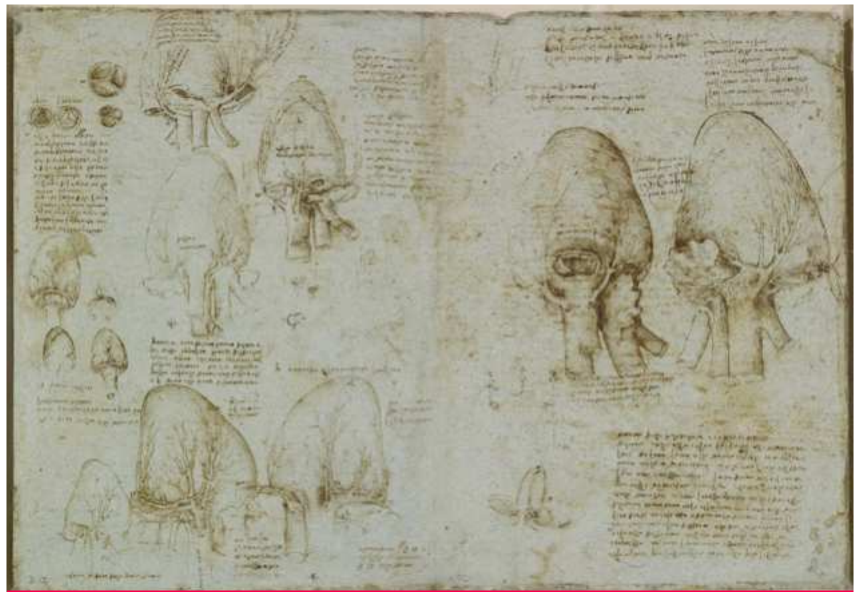
Spotting trouble early: Imagine a tool that could catch issues before they become significant problems. Early disease diagnostics are a bit like a sensitive radar, but one that is affordable to everyone and is fast and easy to use. The goal is to detect irregularities way before individuals feel symptoms or would even think about seeing a doctor for clarification, at which point it might be too late to intervene, as is the case for many cancers. This is a strategy to nip potential health hiccups in the bud, promising help to keep us on the road to well-being. But only if there is a medical treatment strategy available to deal with that very hiccup.

Infrared molecular fingerprinting of bodily fluids, that we are establishing at the Broadband Infrared Diagnostics (BIRD) team, holds promise for all the above-mentioned objectives. It is a new methodological platform that helps pinpoint the healthy ground state of an individuum and trace the earliest instance when a person deviates from his/her personal health trajectory by integrating information from all types of biomolecules in the blood. It is currently maturing through our clinical trials with thousands of individuals.

Specifically, with infrared molecular fingerprinting, we do not search for individual characteristic disease biomarkers but rather agnostically use ultrashort laser pulses to quantify circulating biomolecules of all kinds and classes in our blood in a single measurement – a feature that would otherwise require multiple complex machines and tedious sample pre-analytical steps. Thereby, infrared molecular fingerprinting measures molecules in our blood that stem, in part, from cells and metabolic process from distant organs in our body. In our clinical studies, infrared molecular fingerprinting is trained to relate all the variety and quantities of molecules dissolved in the cell-free partition of our blood to known health and disease states of medially well-studied individuals. This establishes an ever-growing infrared spectral library of diverse health and disease states that is relevant for the medical case applications.

The BIRD-team's nearly decade-long investment in research on applications of infrared fingerprinting in clinical studies to capture infrared spectral changes characteristic of health and diseases, including, cancers of different types, and metabolic aberrations of many kinds. While we have learned a lot already, we still invest in technologically advancing the ultrashort light pulse spectroscopy, to become ever more sensitive in detecting molecules. In parallel, we are still improving our understanding of the peculiarities of infrared molecular fingerprints. We wish to understand their underlying molecular nature and evaluate how robust are the fingerprints in a person over timescales of months and years. For that we perform clinical studies, because individuals are unique and age in person-specific manner. Aging naturally changes the metabolism and thus the infrared molecular fingerprint. Thus, the fingerprint evolves and changes inherently, depending on our bodily makeup and environment. In fact, health is a moving target - a kaleidoscope of our genetic inheritance, history of upbringing and our choice of lifestyle. And infrared molecular fingerprinting is employing computational data analytical tools and techniques to deal with this dynamic complexity.

Defining health still remains a challenge. At which level is health definable as the biological state of any single organ? At which does innervation of organs by the nervous system feed back to a person about its malfunction, i.e. in "dis-ease"? At which level is it better to start fighting already miniscule aberrations that are not yet perceived by pain or functional deficit but can rapidly take over and limit our capacities?



Leonardo Da Vinci was skilled in many disciplines, including anatomy and physiology. At the age of 20, he conducted his first autopsy, for which he received special permission due to the fact that he was an artist. It is not uncommon for artists to perform autopsy studies, but Da Vinci explored anatomy further, taking an interest in internal organs and not just muscle structure.

The heart and coronary vessels (verso) c.1511–13
Leonardo da Vinci (1452–1519) // Pen and ink on blue paper
28.8 × 41.3 cm (sheet of paper)
RCIN 919073 // The Royal Collection Trust

At the end of life, an unclothed corpse is supposed to provide information about life. The contrast to the courtly dressed luminaries of science, who sometimes stare like the unbelieving Thomas at Christ, could not be greater in the picture.

The Anatomy of Dr. Tulp, 1632
Rembrandt van Rijn (1606–1669)
169.5 × 216.5 cm (Oil on canvas)
Mauritshuis, The Hague

In conclusion, at the BIRD-team we explore the multiparametric nature of health with our laser-based methodology of infrared molecular fingerprinting. We wish to achieve better early disease detection, identify individuals at risk, and develop our methodology to be used in high-throughput. The advance of regularly assessing health will be used to become ever more sensitive in tracing deviations from the personal health trajectory. Achieving such investigations demands collaborative efforts. Thus we come from divergent backgrounds, involving laser physics, molecular biology, data science and medicine.

We have come far from judging health by the color of blood, as in ancient wisdom. But maybe such concepts were not far off. It is only that now we start to "see health" in blood in all the colors - and with a quantitative fresh and target-oriented perspective that will potentially contribute to a better molecular understanding of disease development and a handle to help preserve health.

For more information on how the BIRD-team is conducting and technically probing human health and disease, please visit our website: www.attoworld.de/bird

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www.attoworld.de/bird

S4P is an international initiative of scientists and those aware of the role of science and innovation for the future of our civilization. From which this future will grow is education, which is severely impaired in conflict-torn countries. S4P supports these communities to care for the vulnerable and foster education, to open prospects for the future.

Science4People e.V.

empowering children with knowledge and sport

february 2, 2024 // Tanya Bergues

The war in Ukraine is still raging. Help on the ground is more important than ever. Our aid organisation Science4People (S4P) is active there. S4P is committed to promoting education and development opportunities for children and young people in war and crisis regions. S4P has stepped up its efforts and launched two new aid programmes in Ukraine in 2023: SKOLA⁺ and SPORT⁺ aim to increase children's educational opportunities on the one hand and to teach a healthy and active lifestyle on the other. Tanya Bergues coordinates the Science4People aid programmes and reports here on the two new initiatives.

October 2023: S4P & TR launch the SKOLA+ project at two schools in the Batiovo region. Photo: Tabula Rasa for the Future Generation

Younger pupils can also practice at SKOLA+.
Photo: Tabula Rasa for the Future Generation

Initially, we were mainly active in the rural regions in the far west of Ukraine, which was spared direct attacks and has taken in many internal refugees. In the meantime, we have expanded our projects to the region near the front line. With the support of our partners, we also want to bring our aid to these dangerous regions.

The year 2023 began with the planning and preparation of a new educational project to tutor pupils at the two local schools in the Batiovo region. SKOLA⁺ was born. The two small villages of Bakosh and Batiovo have taken in many internal refugees and their children. Some of them stayed there and the children attend the local schools. The young people as well as the children in the region, have experienced considerable trauma and upheaval, first due to the COVID pandemic and then due to the war. Their education is severely impaired as a result.

SKOLA⁺ wants to change this. The initiative focuses on providing comprehensive tutoring and educational resources for schoolchildren, especially children who have fled the war. Their learning deficits are to be compensated for in the long term. At the same time, we want to enable particularly interested children to expand their knowledge beyond the school programme.

The SKOLA⁺-project started in October 2023. It was a success after just three months! By the end of 2023, 165 children (aged between 6 and 17) and 15 teachers were taking part in the project. The additional lessons in a total of 13 subjects are held in small groups (between 5 and a maximum of 15 people). The teachers have complete freedom in their choice of subject matter and in the way they organise the lessons. This allows them to best respond to the needs of the children. The teachers are paid as part of the SKOLA⁺-project and they are provided with all equipment (including office materials, projectors, learning materials, etc.).

The children can take an unlimited number of lessons and attend the tutoring sessions free of charge. SKOLA⁺ is funded by private donations and with the support of the "Sir Peter Ustinov Foundation".

Visiting Bakosh: Students and teachers of the SKOLA^{+}-project together with members of "Tabula Rasa" and "Science4People".
Photo: Tabula Rasa for the Future Generation

Our SPORT^{+}-project is now planned as a counterpart to the SKOLA^{+}-project. It is intended to support various sports such as soccer, basketball and volleyball in the teams in order to promote a healthy lifestyle among young people. At the same time, we are convinced that sporting activities will create a positive psychological balance for the pupils, especially in the current stressful war situation. Last but not least, we want to acknowledge and compensate sports teachers for their commitment and the voluntary work they did so far. At this point, it should be emphasised that both coaches participating in the programme are internal refugees themselves. They are actively involved in the schools

The winners of the regional volleyball competition dedicated to the Day of Physical Culture and Sports, held in Berehove. Photo: Tabula Rasa for the Future Generation

and have already led several sports teams to national success. As part of SPORT^{+}, we have already provided the teams with the most urgently needed equipment.

2024 will continue to be dominated by the focus on education and development. In a broader sense, these projects are our contribution to the country's reconstruction. The rebuilding process should commence now; we cannot wait until "after the war." Our project helps train a new generation of educated, curious young people who will actively participate in rebuilding their country.

We are planning to expand our SKOLA^{+}-project to other schools and regions in Ukraine. SKOLA^{+} will also be launched as a pilot project in one of the schools in Marhanez, near the front line. The situation there is very difficult.

Nevertheless, S4P wants to bring its help there. We are working hard to find additional partners and supporters for this project.

Creative even in the basement: This small group in Marhanets, motivated and supported by their teacher, learns and remains creative despite the missiles flying over their heads. Here with their illustrations of an attosecond pulse in honor of the Nobel Prize laureate. Photo: Tabula Rasa for the Future Generation

general questions and donations:

Tanya Bergues
Email: info@science4people.org

science4people.org

The phone of Ferenc Krausz was ringing all the time shortly after he was awarded the Nobel Prize for Physics.
Photo: Dr. Veit Ziegelmaier

when life takes new paths

january 18, 2024 // Thorsten Naeser

It came unexpectedly. As is so often the case when life takes new paths. On October 3, 2023, the life of Ferenc Krausz has changed. The call came for him from Stockholm at around 11.45 a.m. The Nobel Prize Committee was on the other end. Ferenc had won the Nobel Prize for Physics. As press officer, Thorsten Naeser describes from his perspective what happened in the months leading up to the award ceremony.

The fateful phone call reached me from Garching at 11.45 on 3 October. It was a public holiday and I was sitting in the sandpit. Next to me, my four-year-old son was about to let two toy cars have a proper accident. On the other end of the line was my esteemed colleague Veit Ziegelmaier with the news that our boss had just won the Nobel Prize.

Media rush at the press conference at the Max Planck Institute of Quantum Optics on the day of the announcement of the Nobel Prize in Physics. Photo: Thorsten Naeser

Okay. Now what? It was open day at the Max Planck Institute of Quantum Optics, 25 kilometres away from me. Ferenc wanted to give a talk to a few people there. We planned guided tours with a maximum of 20 participants. So I was at the other end of Munich, safe in the knowledge that everything was in good hands.

After the call, I was gripped by excitement. I had an inkling of things to come. It was a sunny autumn day. And I handed the children over to my girlfriend. Ten minutes later, I was on my bike on the way to Garching, where I arrived an hour later. Because it was clear: the world's press would be gathering here now. My colleagues in public relations and I had to get a grip on them somehow. The first journalists were already there. The cameras were constantly focussed on the newly crowned winner. He could only be seen with a phone to his ear. Despite the commotion, he held his planned lecture in the lecture theatre. However, the room was now bursting at the seams with interested listeners. Just two hours later, we held a press conference in the same lecture theatre. Again, the room was packed. Only then did the tumult die down. The journalists were satisfied. They disappeared into their respective editorial offices. That afternoon was a foretaste of what was yet to come.

Nobel Prize party at the LMU. Photo: Thorsten Naeser

The media from all over the world were literally beating down our doors. Photo: Dr. Veit Ziegelmaier

Over the next few weeks, media from all over the world were literally beating down our doors. Coordinating them was more difficult than herding a bag of fleas. Not to mention, of course, the marathon of interviews this meant for Ferenc. Together with Nicole Buchwiser, Katharina Jarrah, Charlotte Huber and Veit Ziegelmaier, we tried to bring order to the media crowd until the actual award ceremony on 10 December and make it possible for almost everyone to talk to Ferenc.

Then it was finally Nobel Prize week. Yes, that's right! It's not just a simple award ceremony on a nice evening. It's not just a prize being awarded. The highest honour in science is celebrated for a week, culminating in the presentation of the Nobel Prize medal by the Swedish king. All of this takes place in a noble tailcoat, starched shirt and a properly fitted bow tie. The outfit is compulsory for the gentlemen and can be rented on site for for a considerable sum of money.

For an outsider like me and most of my colleagues, this time away from Stockholm was also exciting. Thanks to some videos that Ferenc sent us from Stockholm and numerous YouTube videos from the Nobel Prize organisation, we got few impressions of the events. I've already witnessed many a prize ceremony for my boss. But the Nobel Prize week tops them all. Lectures are held in the run-up to the event, the prize winners give even more interviews than they already did beforehand. There are also discussion rounds in various Swedish institutions such as schools or in the venerable rooms of the Nobel Foundation. One thing is clear: the prizewinners have to achieve quite a lot for the honour that is bestowed upon them and which makes a noticeable difference to their lives.

Shortly after the award ceremony, I browsed the Internet for pictures of the award ceremony. I wanted to collect impressions for this publication, which is now in front of you. I think we can show you some great photos here. I am delighted to be able to review this momentous event for the award winner, but also for all those who were and still are involved.

Ferenc Krausz with Reinhard Kienberger, who is now a professor at the Technical University of Munich.
Photo: Michael Hentschel

Photo: The Nobel Prize organisation

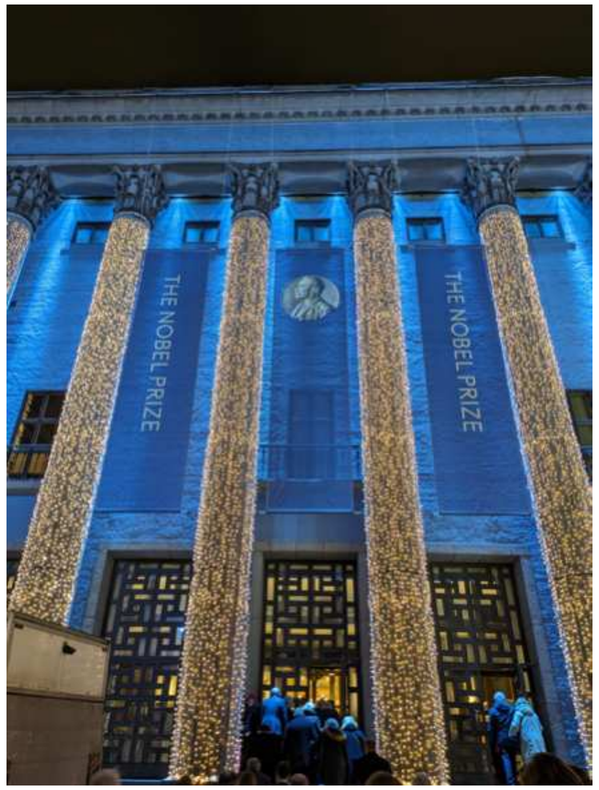


Photo: Angela Krausz

Ferenc Krausz with his wife Angela and the Swedish Royal Family. Photo: The Nobel Prize organisation

Anyone interested in the Nobel Prize winners and their research over the last few decades can find first-hand information on the website of the Nobel Prize organisation. Every year, the laureates introduce themselves personally and report on their work. Ferenc Krausz' detailed contribution will also be available there soon. You can already read the introduction to his contributions here. The QR code at the end of the article will then take you directly to the pages that will be filled in the near future on the subject of attosecond physics and its applications.

we are electrons![1]

december 8, 2023 // Ferenc Krausz

The world that we can observe is made of atoms. Atoms, in turn, are made of a nucleus and electrons bound to it. Outside nuclear reactors (and meanwhile nuclear batteries), nuclei are passive. Beyond defining the mass of bodies they are merely spectators of all the actions undertaken by electrons. In our biological and modern life likewise. So far immeasurably small, yet furnished with a finite mass and electric charge[2], these elementary particles define the functionality of matter. Inorganic and organic matter likewise.

The way electrons organize carbon atoms into different solid structures is responsible for the vastly differing properties of graphite, diamond, and carbon nanotubes (CNTs). Graphite is opaque and soft. Diamond is transparent and the hardest natural substance. CNTs form the strongest material ever discovered, a bundle with 1 square millimetre cross section able to hold the weight of a body of 6 tons. Due to exceptionally strong chemical bonds mediated by electrons. Lubricants, machining tools, and aircraft components, respectively, benefit from these electron-made properties. The oldest known metals, iron and copper contain different nuclei, but it's not this difference that endows iron with higher mechanical hardness especially when mixing it with a bit of carbon (<3%) to turn it to steel. Or renders copper more effective in lowering energy loss upon transporting electric current and transferring heat. It's the electrons!

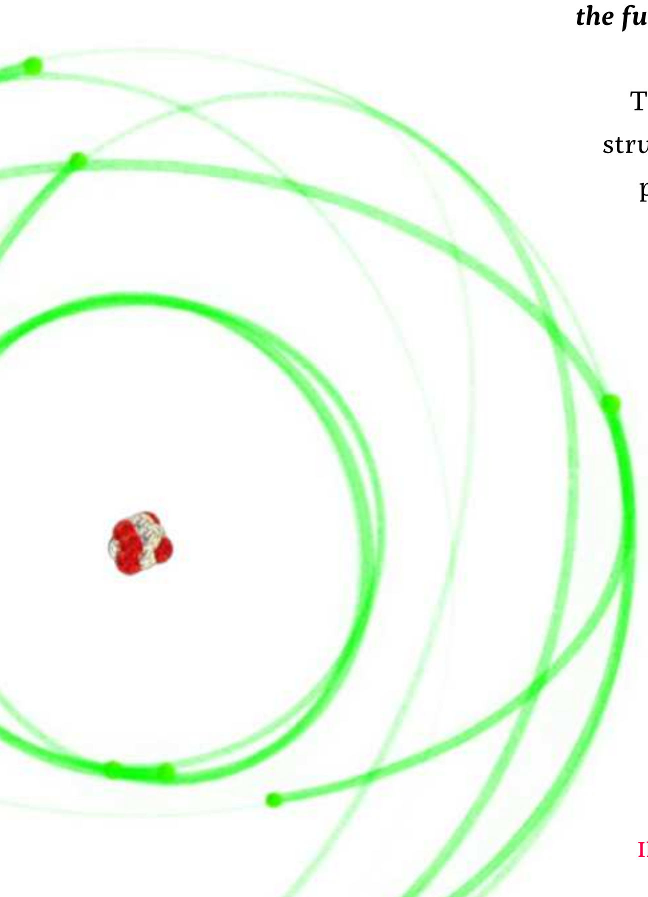


Illustration: Dr. Christian Hackenberger & Dennis J.K.H. Luck

[1] Excerpt from the manuscript of the Nobel Lecture given on December 8, 2023, in the Aula Magna of Stockholm University.
[2] The electron's rest mass is less than half a thousandth of that of a proton, the nucleus of the hydrogen atom. Its electric charge is equal to that of the proton, but opposite (negative) in sign.
[3] The full manuscript will become available on nobelprize.org in April 2024.

Nobel Prize in Physics 2023

Although wires and heat sinks made of copper are essential in integrated circuits, electronic signal manipulation (processing & sensing) is performed by semiconductor devices called transistors. Other nanoscale devices yield the most efficient and versatile light sources, such light-emitting diodes (LEDs), quantum cascade (and other semiconductor) lasers (QCLs) and quantum dots (QDs). The operation of all these devices is enabled by electronic current transported by electrons. Just as transistors are the basic building blocks of electronic devices, biological molecules constitute the basic functional units of living organisms. Electrons dictate their atomic composition and structure via chemical bonds. Nanoscale electronic motion underlies the mathematical operations performed in a computer chip. Atomic-scale electronic motion initiates the alteration of the structure – and hence the biological function – of proteins.

All living creatures, materials, and technical devices are made of electrons. In a sense that they determine their capabilities and performance. All capabilities of living organisms: eating, digesting, seeing, smelling, exerting a force, performing work. Just as the performance of materials: by dictating their physical and chemical properties. Electron-based signal processing forms the basis for our modern life. Signal sensing, in turn, allows collecting information about the world around us. On our planet and beyond. And for collecting information about our health state. Electrons enable the vital functions of organic molecules for creating and maintaining life. All these capabilities rely on electrons. Many of them on *electrons in motion.*

Electrons are ubiquitous – in our biological life and modern life likewise. It is hard to imagine that it wasn't until 125 years ago that humankind became aware of their existence. And it took more than another 100 years to capture their motion. At sub-atomic scales.

Those motions do not only maintain life. They can also generate coherent light. And govern the exchange of energy between light and matter. Harnessing the interaction of coherent light with electrons enables the control of light on the natural time scale of its oscillations. On an attosecond scale. This control, in turn, enables us to capture and control the motion of electrons. In atoms, molecules, as well as condensed matter.

Just as one could not possibly foresee the revolution that the discovery of the electron would ignite in XXth-century science and technology, it is impossible to predict what the greatest benefits from the ability to follow the electrons' motion will be. We shall review some initial returns the real value of which only the future will be able to tell.[3]

read the full manuscript here:

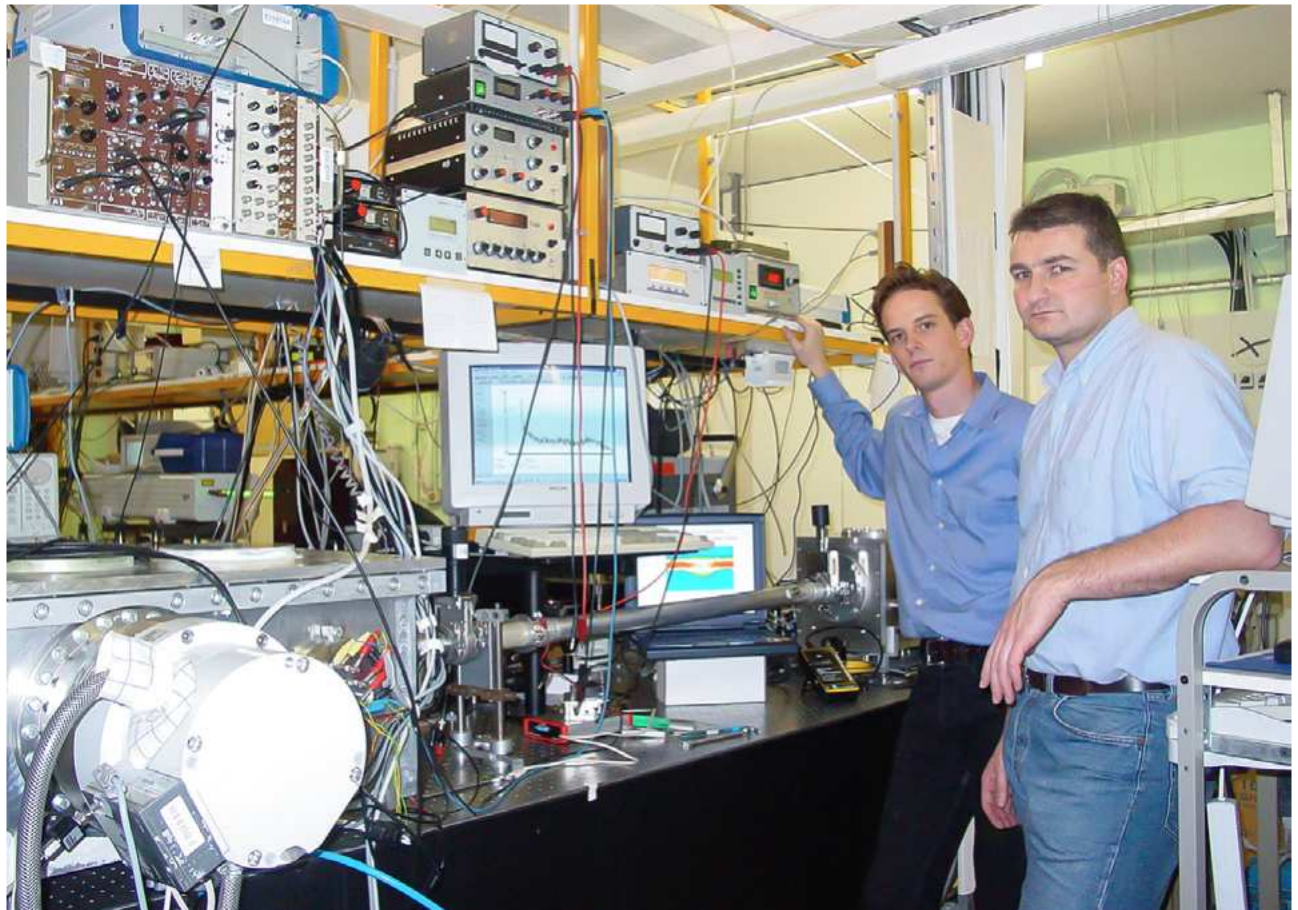
www.nobelprize.org/prizes/physics/2023/krausz

The legendary night of measurements at the "Technische Universität Wien (TUW)" took place at the beginning of September 2001. Ferenc Krausz, Reinhard Kienberger, Michael Hentschel, and Markus Drescher had succeeded in generating the first isolated attosecond flashes of light. Matthias Uiberacker was also very close to the action. At the time, he was writing his diploma thesis in the team of Ferenc Krausz. Here he reports on the legendary events that took place on the very first attosecond beamline on those autumn nights in 2001.

2001 – 2003 the pioneering years of attoworld

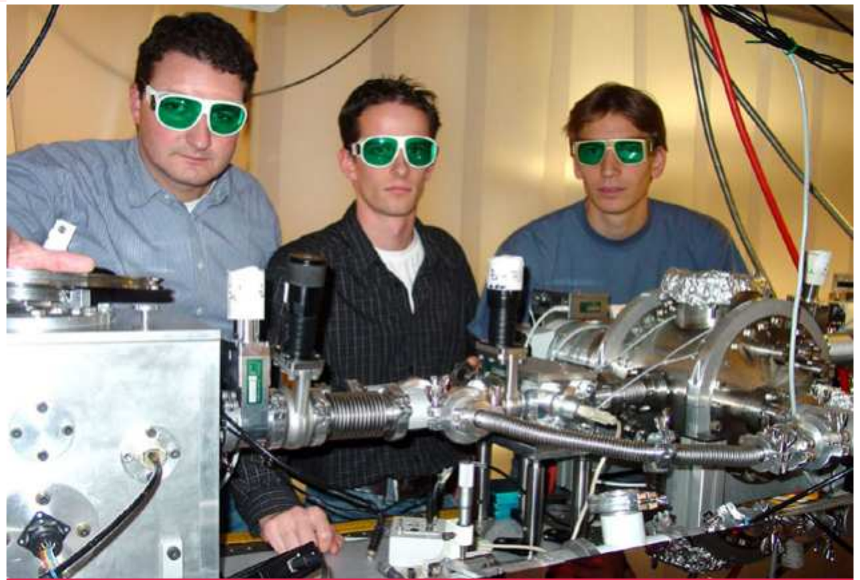
january 22, 2024 // Dr. Matthias Uiberacker

We are in the middle of the year 2001. Having joined Ferenc' team a bit less than a year ago, I was just about to finish my diploma thesis on optimizing the fs-laser focus for the hollow-fiber by a special piezo mirror with multiple controllable sections. My setup was just right next to the main 1 kHz fs laser that shall later be the source for all the breakthrough experiments from the Photonics Lab in Vienna, Austria.



Mike and Reini with the results of the famous measurement night in September 2001 leading to the publication for the Nobel prize. On the left is the experimental chamber and behind Mike the high-harmonics chamber. The CRT screen shows an electron spectrum. The laptop shows the full delay scan. Photos: TU Wien, Institute for Photonics

Right next to me Mike Hentschel and Reinhard Kienberger worked on the "heart of the lab" – the high harmonics beamline that will produce the first sub-fs XUV pulses in the world. Here a great relationship between us took its start and I was more and more becoming a member of the atto team working with them on that very beamline. Experience grew steadily, but I remember well that, when Mike and Reini were at some conference in Kühtai in Tirol, Austria (which was later reported to have been a great skiing experience), Ferenc asked Christian Spielmann and me to try to continue running the beamline in their absence. We managed at least to create the high harmonics and adjust them onto the CCD camera where a micro channel plate converted the XUV to visible light. Although I was sweating bullets to not ruin something by wrong handling of the vacuum equipment or by adjusting the beam foci, it was definitely another good push in experience with the system.



Reini, Mike and me behind the attosecond beamline (from left to right).

This was within the time of early September where I was writing up my diploma thesis when Reini and Mike had that famous measurement night leading to the first evidence of sub-fs structures in the electron spectra and the work published in Nature that finally led to the Nobel prize last year. Soon after that I was also trained well enough to handle also the rear part of the setup including the adjustment of the confocal double mirror illuminating the experimental target and handling the electron spectrometer which was built by Markus Drescher. He dropped by once in a while for a measurement campaign like the famous one leading to the nature publication about the time resolved Auger decay in Krypton. Besides being an expert on atomic physics and spectrometry he was a pretty good whistler. You could often hear nice whistling tunes when he was adjusting some equipment in the lab.

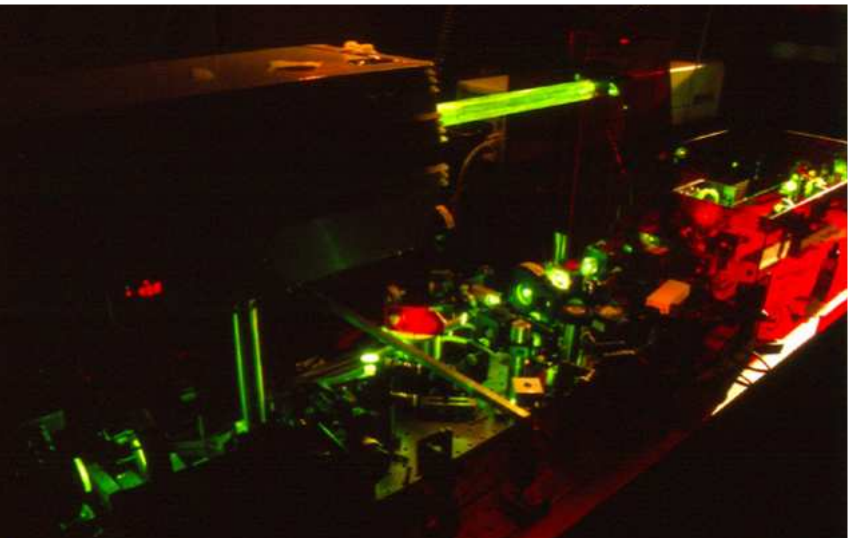
Once, while Markus, Reini and Mike were adjusting the alignment of beam, target and spectrometer, they noticed a strange effect. The laser beam was gone for some short time and then back again. It took the three some moments to find out that the root cause was Ferenc who was standing next to the hollow fiber in-coupling at that time and checking the beam profile with a little sheet of paper every now and then. Markus called this effect the "Zettelchen Effekt". Measurements were mostly done in the night. This had multiple reasons. First the lasers had to warm up to be in shape and not drift away all the time. The warmup was done in the morning: switch on pump lasers in the lab, read emails in the office, go back to the lab to adjust the laser system, then head off for lunch break. Then again adjust the laser to hopefully get a short pulse and finally align the whole setup starting from the hol-

Nobel Prize in Physics 2023

Discussions in the lab: Ferenc and Mike behind him on the left and Markus Drescher on the right. In the background, our friend, the reliable roots-pump which was producing a cosy heat next to the hhg-chamber while measuring through the night.

low fiber, high harmonic generation and electron spectrum. A second reason for the night affinity of the setup was that other coworkers entered and left the lab during the day leading to moving doors and air flow and change in temperature. And thirdly, the underground line U1 was close by and its vibrations also influenced the stability during the day. So only the late evening and night hours could be exploited for having this complex and fragile system running stable enough for a measurement that lasted many hours.

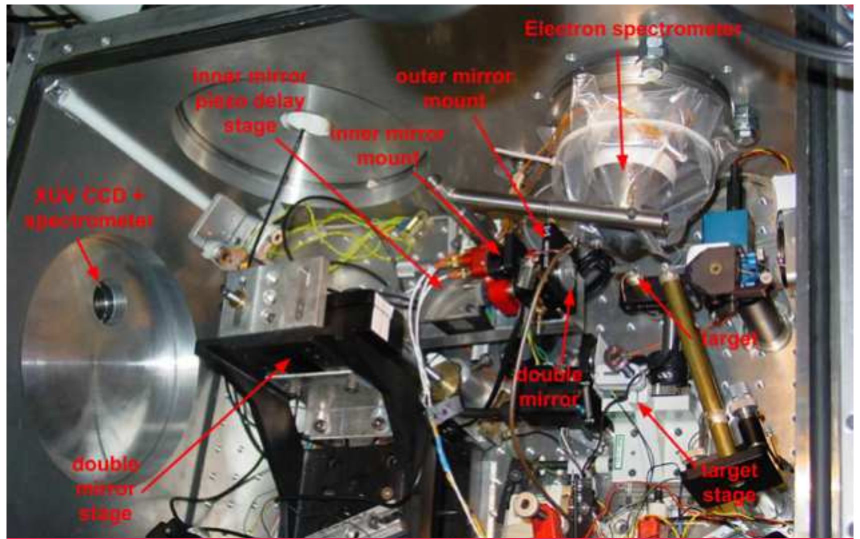
Many evenings and nights we tried to measure if the laser seemed to be in good shape. It was one of those attempts where Ferenc joined us at the end of the working day to check the status of the measurements. Looking at the electron spectrum that was slowly building up due to the low count rate we had, he always saw the success being just around the corner and did a gauss fit nearly on every new electron the spectrometer recorded which added a little rectangle on the spectrum on our screen and commented it with the words "yes I think i see it, yes this is it!". We called this a "Krausz-fit".



The first home-made fs laser setup used for the experiments in 2001–2003.

Another time he was not satisfied with the bad electron count rate and said he wanted to improve the alignment for high harmonic generation "a little bit" and started turning the screws on some mirrors. Finally the high harmonic target had to be replaced, as the hole in it was shot too big by the laser focus during the adjustments. The next day the idea was born among us to add an extra mirror with no real function for such cases – the so-called "professor mirror" – allowing Ferenc to optimize the experiment without danger, but it was never added to the setup.

Comparing our laser and vacuum setup from Vienna with current state-of-the-art attosecond beamlines makes me always a little proud that those measurements have been achieved at that time. The setup was far from perfect and incorporated a lot of improvised, but well working solutions. Once I heard the saying that at TU Wien you might not have that much scientific funding, but you get the skills to make breakthrough experiments out of a tin can and some piece of wire. I would say that fits to how some things were implemented in the experimental chamber. The chamber carries the sounding name "Saug mich 2", as every equipment had to have a unique name for the inventory of the institute. The chamber itself is also a good example for being far from perfect. It was produced by an Austrian company that was good at aluminum welding, but not really experienced in vacuum chambers. The welding seams were mostly tight, but at one position the seam got broken slightly due to the deformations under vacuum. As we didn't know where exactly the untight spot was, nearly the whole welding seam was covered with torrseal, a hardening glue for vacuum equipment.



Experimental chamber "Saug mich 2" with descriptions of the main components.

The rough position of the spot was found with overpressure tests. At one of those tests, one of the two plexiglas windows in the top lid, which were held in place by only some silicone glue, came off with a loud bang and even hit the ceiling of the lab. Fortunately no one looked through it at that time. Finally we managed to get the vacuum down to about 10e-6 mbar and the limiting factor were rather the components inside the chamber which were not all perfectly suited for high vacuum (e.g. see the sticky tapes with some labelling on them). Markus Drescher tested this on various things that were meant to go into the chamber by simply using his nose. While sniffing on some component he told me: If it smells, it is not good for vacuum.

All in all it was such a great time and experience for me, especially when I was working together with Mike and Reini on the first experiments. And great times followed with more scientific breakthroughs together with Eleftherios Goulielmakis on roughly the same but further improved setup and a new laser on which Andrius Baltuska and his colleagues managed to phase stabilize the pulses.

Soon after that period our time in Vienna came to an end and we were seeking out to new horizons. Ferenc was appointed to become one of the 5 directors of MPQ and asked us to join him there. This was of course an opportunity that most of us could not resist and I had a great time the following years in Garching within the ATTOWORLD.

Looking back through all those years I'm happy and thankful that I could be part of all this, that I had a great team, that I had a great boss and that all of it now even peaked in Ferenc receiving the Nobel prize.

Dr. Matthias Uiberacker

with many thanks to Mike Hentschel, who was able to fill in some gaps in the author's memory

Photo: Samuel Pettersson/Umeå University

happy reunion

december 18, 2023 // Thorsten Naeser

Ferenc Krausz had a happy reunion with an old companion on his lecture tour of Sweden in December. After many years, he met his former colleague Prof László Veisz at Umeå University (UU).

During a lab tour in the morning he was most impressed to see the technology László initially demonstrated at MPQ to come to fruition. At UU, László and his team has developed the world's first near-single-cycle, waveform-controlled high-power (multi-terawatt) laser source. The system opens unique research opportunities for extending attosecond physics to relativistic interactions, in which electrons are accelerated to velocities near the speed of light within one oscillation period of laser light. These conditions may pave the way towards the generation of attosecond pulses in the regime of soft to possibly even hard X-rays.

In the afternoon, the Nobel Laureate gave a lecture in a nearly full Aula Nordica, where he began by paying tribute to László Veisz's research. "What László and his colleagues are doing at the lab here is the future. There is not even a runner up; the laser that Umeå University has is unique in the world and I am very proud of my former colleague", Ferenc said enthusiastically.

Matthias Kling elected as a Fellow Member of Optica

november 13, 2023 // Thorsten Naeser

Photo: private

The Board of Directors of Optica elected 129 members from 26 countries to the Society's 2024 Fellow Class. Matthias Kling is also among the chosen ones this year. Matthias is being honored specifically "For seminal contributions to field sampling at optical frequencies reaching attosecond temporal and nanometer spatial resolutions." Optica Fellows are selected based on several factors, including outstanding contributions to research, business, education, engineering and service to Optica and the Laser Community.

"Congratulations to the 2024 class of Optica Fellows," said Michal Lipson Optica President in 2023. "It is a pleasure to honour these members who are advancing our field and society. We are grateful for their exceptional work and dedication."

Fellows are Optica members who have served with distinction in the advancement of optics and photonics. As Fellows should account for no more than 10 percent of the total membership, the election process is highly competitive. Candidates are recommended by the Fellow Members Committee and approved by the Awards Council and Board of Directors.

The new Fellows will be honoured at Optica Conferences and events throughout 2024.

Photo: Thorsten Naeser

a returnee from the pioneering days

january 18, 2024 // Thorsten Naeser

The ATTOWORLD-team welcomes a returnee from the pioneering days: Prof. Alexander Fuerbach from Macquarie University in Sydney. When Ferenc and his team produced the first attosecond flashes of light in 2001 at the University of Vienna, Alexander Fuerbach was a doctoral student in the research group.

He has now returned to complete a sabbatical in Alexander Weigel's group until July. During this time, Alex Weigel and Alex Fuerbach want to work together to increase the output power of the infra-sampler.

"I'm looking forward to working in the ATTOWORLD-team again," says Alex Fuerbach. "I'll be on long service leave from mid-July, as I've been working at Macquarie University for almost 20 years, so I've accumulated a lot of time. If I am still needed then, I could well imagine staying with the team even longer."

attoworld retreat 2023: science, magic and wanderlust

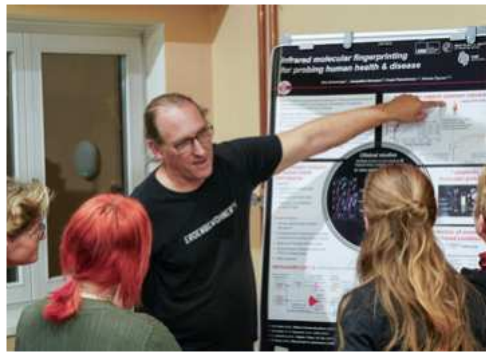
october 25, 2023 // Dr. Veit Ziegelmaier

After the years of pandemic, this time's ATTOWORLD-retreat could finally took place again at an inspiring location outside the institutes. As in 2019, the choice fell on St. Johann im Ahrntal in South Tyrol, where we were able to enjoy the hospitality of the people running Hotel Steinpent.

From October 8 to 12, an intensive seminar program took place with informative presentations from all sectors of ATTOWORLD and scientific lectures by the respective research group leaders as well as the associates who had traveled there to join us, such as Prof. Stefan Karsch and PD. Dr. Ioachim Pupeza. The lectures provided information on the current status of research and gave an outlook on future developments. A lively exchange of reflections in the plenary rounded off the presentations. In the evenings there were also poster sessions where all researchers within the groups presented their current projects. But there was also enough time for socializing later on. Of course, we toasted the Nobel Prize again with Hungarian wines and delicacies, which Ferenc had specially brought from his home country.

And we should also mention our free day, when most of us went for a breathtaking hike on Speikboden, a beautiful mountain in the region. And of course a lecture on human perception by Thomas Fraps, which was enriched by striking tricks of the art of magic. Furthermore, we had the pleasure to welcome a delegation of our Hungarian colleagues from CMF, who joined this year's ATTOWORLD-retreat. We hope to repeat this event next year!

Photos: Thorsten Naeser & Dennis J.K.H. Luck



attoworld comes to Poland

january 22, 2024 // field-resolved infrared spectroscopy

Our former colleague, Maciej Kowalczyk, is currently running a Max Planck Partner Group at Wrocław University of Science and Technology in Wrocław, Poland. Within this 5-year-long project his group is developing ultrastable chromium lasers for the next generation Infrasampler technology.

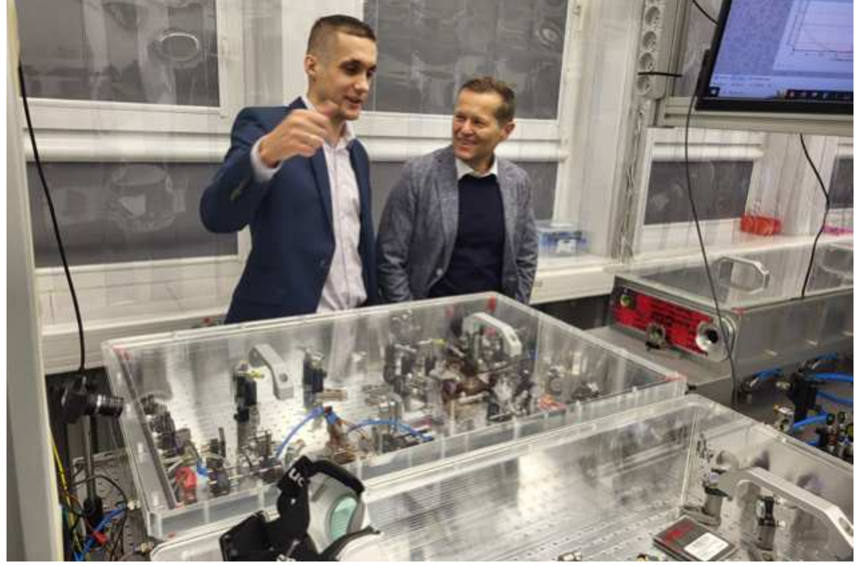
Maciej Kowalczyk has been working as a postdoctoral researcher in the group of Dr. Alexander Weigel between 2020 and 2023. During his time in the ATTOWORLD he focused on phase stabilization of chromium-doped ultrafast lasers[1], a crucial step towards implementation of this class of oscillators in the next generation Infrasampler 3.0. Together with other ATTOWORLD-members, Philipp Steinleitner and Nathalie Nagl, he came up with a novel technique for the generation and precise control of single-cycle mid-infrared electric-field waveforms[2].
In 2023, Maciej decided to come back to his Alma Mater, Wroclaw University of Science and Technology, where he got his PhD diploma. Maciej successfully applied to The Polish National Agency for Academic Exchange for the research grant "Polish Returns"[3]. He was one of the nine awardees to receive a funding of roughly 250,000 €, which helped him to initiate a new laser laboratory in a larger team led in Wrocław by Prof. Jarosław Sotor.

"The majority of my activities in 2023 were devoted to starting a new lab." – Maciej reported – "There were countless issues to be organized: from room renovation, through inserting an optical table via a lab window, to designing table enclosure and choosing lab shelves. After devoting all my time to scientific work in the previous postdoc years, it was a bit intimidating at first, but I soon realized, that if I want to run a group, there is no other choice but to master my organizational skills."
In the meantime, Maciej's efforts were rewarded with another research grant, this time from the Max Planck Society (MPG) within an International Max Planck Partner Group programme. This prestigious, 5-year-long project supports establishing a junior research group by a former Max Planck early career scientist, who will closely collaborate with one of the MPG institutes. Within the project entitled "Ultrafast chromium lasers for field-resolved spectroscopy of biological systems", the Partner Group led by Maciej in Wrocław, will work together with the ATTOWORLD-team from Max Planck Institute of Quantum Optics towards a common goal.

"My research activities in Wrocław will be a direct continuation of what I focused on in Garching." – Maciej continues – "We will develop new techniques of stabilization for ultrafast chromium lasers, which will allow unprecedented performance regarding both phase and amplitude stability. Subsequently, our ultrastable lasers will be employed by the MPQ Team in the next generation Infrasampler for probing human health."

The new laboratory has been initiated on November 7, 2023, by Prof. Ferenc Krausz. His visit in Wrocław began with the lecture "Attosecond Science: From Speeding Up Electronics to Probing Human Health", which he gave to roughly 600 people in the audience, including tens of school pupils. Afterwards, he officially opened Maciej's Max Planck Partner Group laboratory, in the presence of the rector of Wrocław University and many polish media reporters, who were eager to interview the recent Nobel Prize laureate.

"Currently, the team consists of my first PhD student, Karolina Suliga, but we already had two student interns. The lab is fully operational and we already have two running chromium mode-locked lasers." Maciej concludes: "I feel very privileged to be given a chance to continue this exciting research in Poland together with the ATTOWORLD-family. I am sure the future will bring us many exciting findings important to both: the fundamentals, as well as applications of laser science."



Photos: Wrocław University

attoworld.de/fris

[1] www.attoworld.de/news/research/article/cep-stable-single-cycle-pulses-on-the-months-cover-of-optica.html
[2] www.attoworld.de/news/team/article/controlling-the-waveform-of-ultrashort-infrared-pulses.html
[3] www.attoworld.de/news/team/article/return-to-wroclaw-tech.html

team news

"if anyone is in the area, I would be happy to give you a tour of our lab."

january 2, 2024 // asst. Prof. Shawn Sederberg

After several years working in the ATTOWORLD-team Shawn Sederberg went back in his homeland Canada in 2017. There he worked in the group of Paul Corkum before he joined Simon Fraser University (SFU) in Vancouver as a professor. Here he reports what life is about in Canada and what he is now working on. He would also be pleased to receive visits from ATTOWORLD-members in Canada.

My last day in the ATTOWORLD was quite surreal. Not just because of my overall experience there, but because we had finally succeeded in performing an attosecond measurement in ambient lab conditions – a measurement of the time delay incurred by electrons while undergoing a transition from the valence band to the conduction band of quartz. Although an obvious trend had been observed from our earlier attempts to complete the 8-hour measurement, we still hadn't captured the publication-worthy dataset, free from environmental drifts. After 3,5 years of effort, it was a huge relief to have the final measurement that we would need to for our future publication.

Most of the progress had happened within the last six months and, in many regards, it wasn't the ideal time to leave. However, with our second baby on the way and an already-too-small apartment, we decided to make the transition back to Canada in August 2017. I spent the next four years working in the group of Paul Corkum before I joined Simon Fraser University (SFU) in Vancouver as an Assistant Professor.

There are surprisingly quite a few similarities between Vancouver and Munich. Both are highly international cities that offer an excellent quality of life. The area we live in is particularly international and many students in my children's school weren't born in Canada. They have discussions about their diverse backgrounds as a class. Through these, my Munich-born son has concluded that he is actually German, not Canadian. The weather is also quite comparable, with beautiful summers and relatively mild winters, at least by Canadian standards. Excellent skiing and other outdoor activities are also just a short drive away in both locations. Beautiful mountains are visible from Vancouver when the sky is clear and an ocean inlet is easily accessible. As with Munich, the price tag that comes with this lifestyle is also quite high. As a relatively young city with young universities, Vancouver doesn't have the same academic atmosphere as Munich but, at the same, this leaves some opportunities to develop new research directions in the region.

The social system in Canada isn't quite as advanced as in Germany. Although Vancouver has excellent public transportation by Canadian standards, it was much better in Munich. As well, accessing the health care system is not as straightforward in Canada. Unfortunately, Canada is falling behind other advanced countries in key areas such as addressing climate change, national defense, and funding scientific research. Although SFU is not recognized internationally for its excellence in laser science, it does have one notable link. The inventor of the laser, Theodore Maiman, lived in the Vancouver area in his later years and was an Adjunct Professor at SFU. Anyone who visits MPQ has the opportunity to view the laser that he invented, along with his lab book. Prior to finding its new home at MPQ, where it undoubtedly receives the appreciation it deserves, Maiman's laser was here at SFU. Although we no longer have the original, I'm planning to create a replica to put on display in honour of the time that Maiman was here.

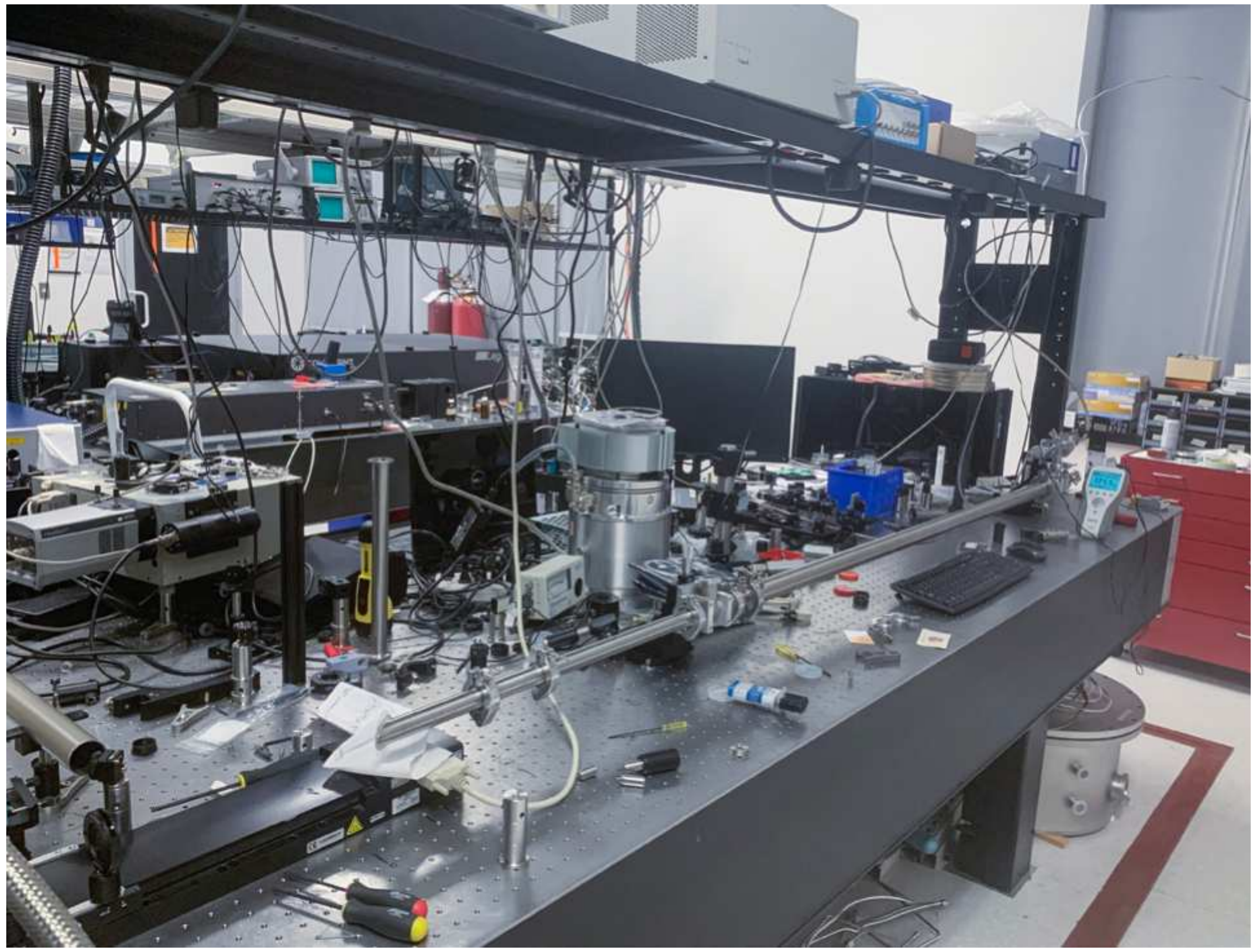


Photo: SFU/Sederberg Photonics Lab

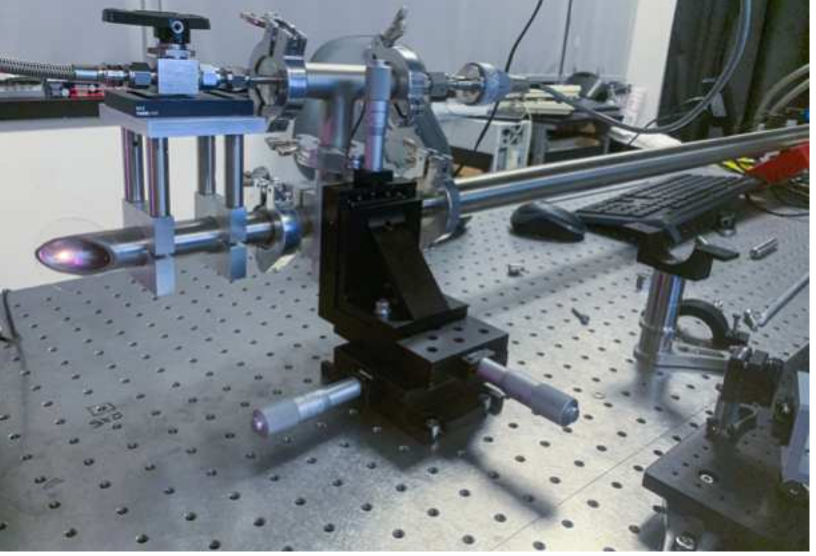


Photo: SFU/Sederberg Photonics Lab

I was given the opportunity to build my lab infrastructure within an existing laser facility at SFU. This space houses several femtosecond laser systems and features vibrationally isolated floors, a relatively high ceiling, a >200 m² footprint, and air conditioning, making it well-suited for attosecond spectroscopy. The existing laser systems give us the opportunity to start working on some experiments before our own laser arrives. Although the first couple of years have been quite intense with learning the teaching role, recruiting and training students, applying for funding and ordering equipment, we're now making progress on a beamline for attosecond spectroscopy based on pulses from an amplified Ti:Sapph laser. Since working with FP2 at MPQ, I've grown to appreciate that there probably isn't another beamline quite like it in the world and it is a strong source of inspiration for the beamline that I'm currently working on.

Our first efforts will be devoted to developing short pulses and waveform sampling tools, including nonlinear photoconductive sampling and electro-optic sampling. We will also explore the possibility to perform nonlinear compression of structured light beams and to sample their spatio-temporal fields. One of our main goals is to harness the magnetic fields of structured light pulses for steering magnetic-field-sensitive processes in solids on previously unexplored timescales. We hope to complement some of our experiments with the unique capabilities provided by the TRIUMF particle accelerator facility in Vancouver, particularly muon spin resonance measurements.

The Nobel Prize in Physics announcement was of course very exciting this year. I'm extremely honoured to have been a member of Ferenc's group for a few years and to have learned so much there. Each year, my university organizes a Nobel Prize Talk Event for the general public at the Vancouver Science World. I will have the opportunity to present about the Nobel Prize in Physics this year.

I really enjoy the occasional discussion with a former colleague from MPQ and to hear about their latest experiments, either at MPQ or elsewhere. It's also great to unexpectedly bump into someone at a conference. Vancouver does occasionally host conferences, so if anyone is in the area, I would be happy to give you a tour of our lab.

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Ferenc Krausz receives the "Maximiliansorden of Bavaria"

february 7, 2024 // Charlotte Huber

"Nobel Prize in white and blue": Minister President Markus Söder presents Ferenc Krausz with the Bavarian Maximilian Order. Photo: Thorsten Naeser

Ferenc Krausz has received the prestigious "Maximiliansorden". With this award, the Free State of Bavaria honours his pioneering work in the field of Attosecond physics. Prime Minister Markus Söder presented the "Maximiliansorden" in person at the Bavarian State Chancellery.

The Bavarian Maximilian Order for Science and Art, which Markus Söder described in his speech as the "Nobel Prize in white and blue", is the highest state honour that researchers and artists can receive in Bavaria: "It is a prize that you cannot buy or inherit, but that you have to earn," Söder explained at the award ceremony.

"I would like to thank you very much for this award. It is a great honour to be included among the illustrious recipients of this medal," explained Ferenc Krausz in his acceptance speech, "and I would also like to thank the excellent research conditions in Bavaria."

The Bavarian Maximilian Order was originally founded by King Maximilian II of Bavaria. It has existed in its current form since 1980, and the number of living recipients is limited by law to 100. In addition to Ferenc Krausz, the MPQ directors Immanuel Bloch and Theodor Hänsch have also received this high honour.the lab here is the future. There is not even a runner up; the laser that Umeå University has is unique in the world and I am very proud of my former colleague", Ferenc said enthusiastically.

Following the award ceremony, Ferenc Krausz took part in the Cabinet meeting Photo: Bayerische Staatskanzlei

Following the award ceremony, Ferenc Krausz took part in the Cabinet meeting: "Today we had one of the world's brightest people as a guest in the Cabinet. His Nobel Prize is a task and an incentive for Bavaria so that we can continue to offer the best conditions for the best research with our high-tech agenda," reads the official statement by Minister President Markus Söder.

behind the visible

january 2, 2024 // A. O.

Our website www.attworld.de is the central communication tool of our group. Here we tell you a little bit about the history of the website and explain which programs are used to run it.

For the development of ATTOWORLD, various programs are used, ranging from initial conception to UML and other graphical representations of functionality to actual implementation. We use an Integrated Development Environment (IDE) for programming, which automates numerous individual tasks such as version control, data management for clients and servers, project management, meta-data creation and analysis, and more.

Web applications differ in several aspects from traditional software. The differences from software engineering are mainly due to the use of hypermedia documents, which, along with the browser, form the user interfaces, as well as the underlying network architecture with the client/server paradigm, HTTP or TCP/IP protocol, and address resolution via the Domain Name System.

The ATTOWORLD-website is based on all of these concepts. Web applications also require user models since document-based or system-based user management is not common on the World Wide Web, and each application must ensure user identification if necessary. ATTOWORLD uses the Typo3 Content Management System, which, as a framework consisting of HTTP, PHP, HTML, CSS, JavaScript, Java, XML, SQL, and others, forms the purely technical level and enables content maintenance and website administration through these technologies via the process level – called the backend.

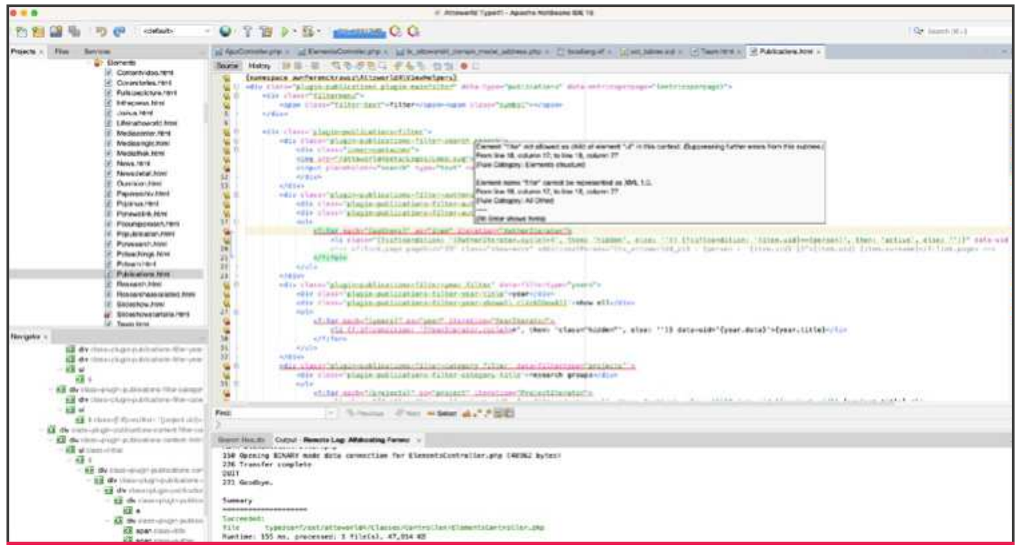
Typo3 Content Management System

TYPO3 CMS is a free content management system for websites, officially offered under the name TYPO3 CMS since October 2012. TYPO3 was originally developed by Kasper Skårhøj. The core of TYPO3 is written in the PHP scripting language, and the browser output is done using HTML and JavaScript. Common SQL-based databases like MySQL can be used as the database, and the connection is abstracted through Doctrine DBAL.

team news

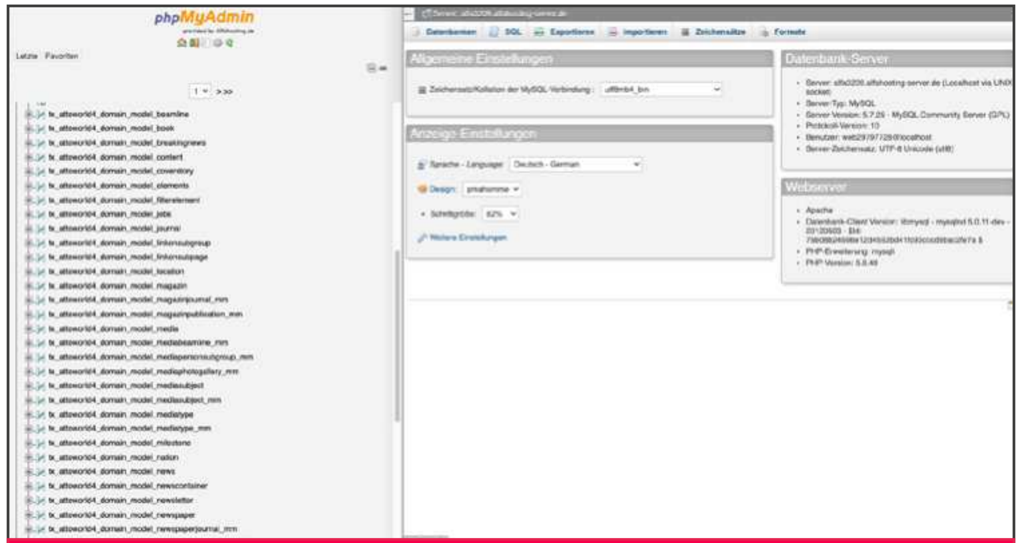
From 2007 to 2015, TYPO3 was continuously developed by two core development teams. One team focused on "TYPO3 CMS", while the other worked on the newer "TYPO3 Neos." In 2015, Neos separated from the TYPO3 Association and has since been developed as its own product. The protected trademark TYPO3 has also served as a home for a range of other products since October 2012.

Numerous TYPO3 functions can be integrated with extensions without the need to write custom code. Most of the currently over 5,000 extensions come from third-party developers and are freely available. Extensions for news, e-commerce systems, or discussion forums are available, among others. The system is designed for multilingual use and is supported by a global community of users and developers. An incomplete study conducted up to July 2020 found approximately 275,562 TYPO3 installations on the internet, with a disproportionately high number in the German-speaking region. TYPO3 is thus one of the most well-known content management systems in the field of open-source software, along with Drupal, Joomla, and WordPress.



The HTML template shown generates the frontend output for the attoworld publication subpage. The template language opimized for TYPO-3 is called Fluid. For example within the displayed <f:for ...> the f: indicates Fluid.

The Fluid Template Engine powers modern TYPO3 websites and provides a fast way to customize HTML-based output for any PHP-based project. Originally part of TYPO3 Neos and TYPO3 Extbase and invented in 2008 by Bastian Waidelich and Sebastian Kurfürst, Fluid has conquered the TYPO3 world in recent years and is now the basis for all rendering in the frontend output and the TYPO3 administration interface. In 2016, Claus Due refactored the codebase into a standalone package, which has been used as a library since TYPO3 v8, just like the Neos/Flow Framework.

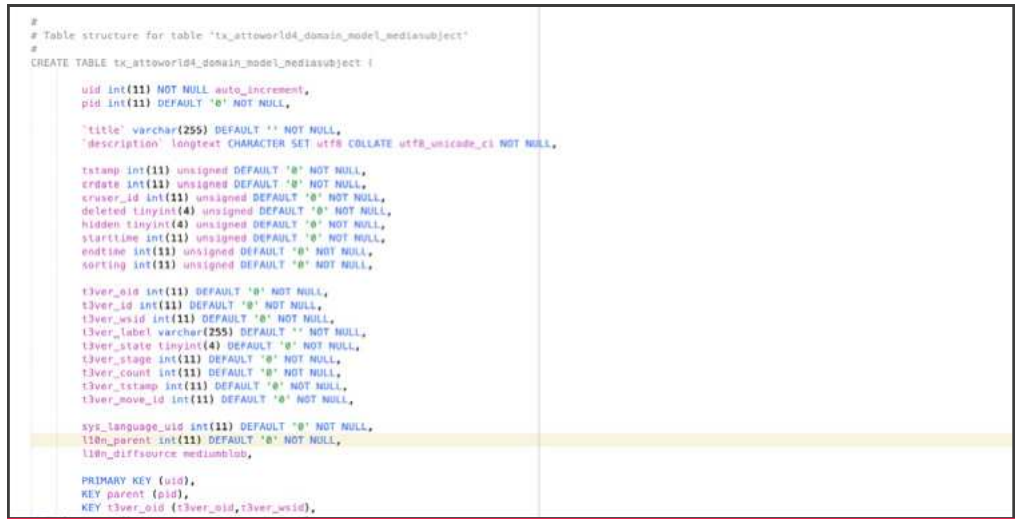


The MySQL database is managed using the phpMyAdmin tool. Here you can define basic settings for the database, such as the default character set UTF-8.

The attoworld Database System

ATTOWORLD uses a MySQL database, the de facto standard for Typo3 installations. The Typo3 MVC model forms the basis for this. The MVC concept was originally described in 1979 for user interfaces in Smalltalk by Trygve Reenskaug (Seeheim model), who was working on Smalltalk at Xerox PARC at the time. It has since become the de facto standard for the high-level design of many complex software systems, sometimes with differentiations and often with multiple modules divided according to the MVC pattern.

For data storage, entities are formed into objects at ATTOWORLD, for example, a publication is an object, and individuals are another object. The two objects are linked for the author listing of publications. This is done so that if something changes in the data, for example, in the publication or the author, it can be updated centrally in one place, and all data outputs in the frontend will be automatically updated.

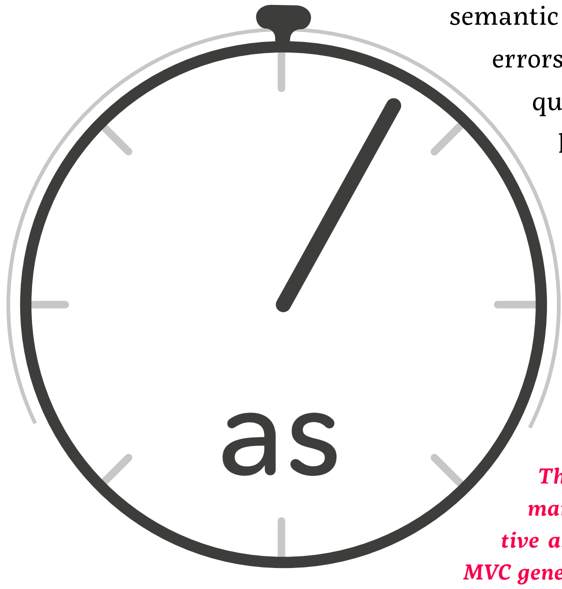


```
#
# Table structure for table 'tx_attoworld4_domain_model_mediasubject'
#
CREATE TABLE tx_attoworld4_domain_model_mediasubject (

	uid int(11) NOT NULL auto_increment,
	pid int(11) DEFAULT '0' NOT NULL,

	`title` varchar(255) DEFAULT '' NOT NULL,
	`description` longtext CHARACTER SET utf8 COLLATE utf8_unicode_ci NOT NULL,

	tstamp int(11) unsigned DEFAULT '0' NOT NULL,
	crdate int(11) unsigned DEFAULT '0' NOT NULL,
	cruser_id int(11) unsigned DEFAULT '0' NOT NULL,
	deleted tinyint(4) unsigned DEFAULT '0' NOT NULL,
	hidden tinyint(4) unsigned DEFAULT '0' NOT NULL,
	starttime int(11) unsigned DEFAULT '0' NOT NULL,
	endtime int(11) unsigned DEFAULT '0' NOT NULL,
	sorting int(11) unsigned DEFAULT '0' NOT NULL,

	t3ver_oid int(11) DEFAULT '0' NOT NULL,
	t3ver_id int(11) DEFAULT '0' NOT NULL,
	t3ver_wsid int(11) DEFAULT '0' NOT NULL,
	t3ver_label varchar(255) DEFAULT '' NOT NULL,
	t3ver_state tinyint(4) DEFAULT '0' NOT NULL,
	t3ver_stage int(11) DEFAULT '0' NOT NULL,
	t3ver_count int(11) DEFAULT '0' NOT NULL,
	t3ver_tstamp int(11) DEFAULT '0' NOT NULL,
	t3ver_move_id int(11) DEFAULT '0' NOT NULL,

	sys_language_uid int(11) DEFAULT '0' NOT NULL,
	l10n_parent int(11) DEFAULT '0' NOT NULL,
	l10n_diffsource mediumblob,

	PRIMARY KEY (uid),
	KEY parent (pid),
	KEY t3ver_oid (t3ver_oid,t3ver_wsid),
```

The extract shown contains the basic structure of the individual attoworld database tables within MySQL, here as an example the categories for the upcoming media library. The default value for most table fields is the numeric '0'. 'NOT NULL' means that the nothing (NULL) defined in computer science is not used.

A permanent challenge

In conclusion, the challenge in development primarily lies in meeting the requirements while also implementing them in a technically sensible way and following all specifications. Since practice has shown that requirements change very quickly or new requirements arise, an additional challenge is managing the complexity that results from this. As the complexity rise so the challenge become overwhelming and no longer manageable. To illustrate this, consider the difference between semantic and syntactic errors: Syntactic errors, such as grammatical errors, are quickly detected, and there are tools to find and fix them quickly and effectively. Semantic errors, on the other hand are hidden in complexity – in literature they are often logic errors in the story – and often come with performance problems as complexity increases.



The programming paradigms used offer many advantages, but also have some negative aspects. For example, modeling based on MVC generates a kind of bottleneck due to the way in which the database is accessed in controlling. This can lead to considerable performance problems, which can only be solved by combining different programming paradigms, which in itself leads to greater complexity. In combination with a dynamically changing project concept, there is unfortunately always the danger that the complexity becomes so high that it can hardly be mastered. Many ambitious projects in the field of software development therefore often collapse due to the creative elite's enthusiasm for decision-making. So we also had to finally admit defeat and were able to reduce the loading time of attoworld from many to just a few seconds, but sadly not to attoseconds.

www.attoworld.de

“A task that will keep us busy for a long time.”
[Dr. Nathalie Lenke]

january 2, 2024 // Thorsten Naeser

Last summer, PULSED employees had reason to celebrate. The company had its first anniversary and an exciting founding year behind it. As a spin-off from the ATTOWORLD-group, PULSED has specialized in ultrashort pulse lasers for infrared spectroscopy and ultrafast laser physics. Dr. Nathalie Lenke is one of the early employees. In the following, she explains how the idea to launch PULSED came about and how the start-up company strives to develop devices for health monitoring and early disease detection.

The company PULSED has been around for over a year now. Where can you place the company in the large landscape of laser technology developers?

That’s right, we celebrated our first birthday at the half-year mark! In the early days, we were busy setting up the company organizationally. But, I think it’s amazing how much you can achieve in just one year and how quickly we grew into a strong team! In the meantime, all the foundation processes have been completed and we already have orders. Compared to long-established laser companies, we are of course still quite small, but our workhorse is a laser system whose parameters are not yet available on the market and which is therefore highly interesting for many research groups. This gives us a technological edge that secures us a place in the market despite great competition!

How did the idea of setting up in this particular niche of photonics come about?

The basic idea had existed for some time. The ATTOWORLD-group, from which all current PULSED employees come, is one of the world's leading groups in the field of ultrafast laser physics and has enormous know-how in laser technology development. Because we closely follow the publications and presentations of our international colleagues, we can see both what laser systems are currently available to the community and what laser parameters would be beneficial for their experiments. PULSED was also founded with the idea of making our university group’s laser technology available to a wide range of users outside of ATTOWORLD. This allows our customers to focus more on their own experiments and less on laser development.

The final spark then came from the extremely motivating research results around the medical application of molecular fingerprinting. Our long-term goal is to be able to offer devices for medical applications for health monitoring and early disease detection. Of course, this is a task that will keep us busy for a long time, but we are currently in the process of laying a solid foundation for it!

What distinguishes your lasers?

On the one hand, our strength lies in the generation of ultrashort laser pulses with pulse durations of less than ten femtoseconds. This corresponds to pulses shorter than 10^{-14} seconds and enables measurements with unprecedented time resolution.

What is also special is that these pulses are generated in the infrared. Most (commercial) laser systems generate light at shorter wavelengths or with much longer pulse durations. However, for a number of applications, the infrared range is of great interest because infrared laser light can be used to excite many different molecules in a sample. This makes it extremely interesting not only for medical, but also for a number of other spectroscopic applications.

Moreover, these laser pulses are generated with particularly low “noise” and high reproducibility. This creates an important prerequisite for performing spectroscopic measurements with very high sensitivity. With our phase stabilization technique, the ATTOWORLD-group has demonstrated the lowest phase noise ever measured for such lasers. This means that these lasers can generate pulses whose electric fields look exactly the same. This is a basic requirement for many experiments.

Last but not least, it is also the compact and extremely robust design that distinguishes our lasers. We place a lot of emphasis on the mechanical design of the laser in order to provide users with a user-friendly system that is as maintenance-free as possible.

Can you describe how your lasers work?

The heart of our system is a laser crystal made of chromium-doped zinc sulfide (Cr:ZnS), which we irradiate and optically excite with a commercial laser. The crystal is located in a so-called resonator – an array of mirrors with special coatings. This “traps” the light emitted by the crystal so that the light passes through the crystal several times and gets amplified. To generate high-intensity light pulses, we then need to put the laser into pulsed mode by rapidly moving a resonator mirror. Finally, to use the light pulses for experiments, a mirror in the resonator is partially transparent, such that a small part of the light can escape from the resonator. The light pulses

Laser development in the laboratory. Photo: Thorsten Naeser obtained are already very short, but their spectrum is not yet broad enough to perform phase stabilization with them. Therefore, the light is passed through another crystal to broaden the spectrum, giving it more spectral components (more infrared "colors"). Specially coated mirrors ensure that all these spectral components remain compressed in a short pulse. The last element of the laser deals with phase stabilization, which ensures that the electric field of each laser pulse looks exactly the same. But to explain this element in more detail, you'll have to come visit us in the lab!

How long does it takes to develop such a technology?

It takes years for research to lay the necessary foundations. Only then can you take the second step and convert existing structures into more compact, more stable and easier-to-operate systems. In technical jargon, this is referred to as passing through the "Technology Readiness Levels" (TRLs). In university research, one usually gets to TRL 4 or 5, i.e. one provides experimental "proof of concepts" and has built first demonstrators. All further steps up to TRL 9, i.e. a certified and saleable product, are then the task of companies like PULSED and require another 1–2 years.

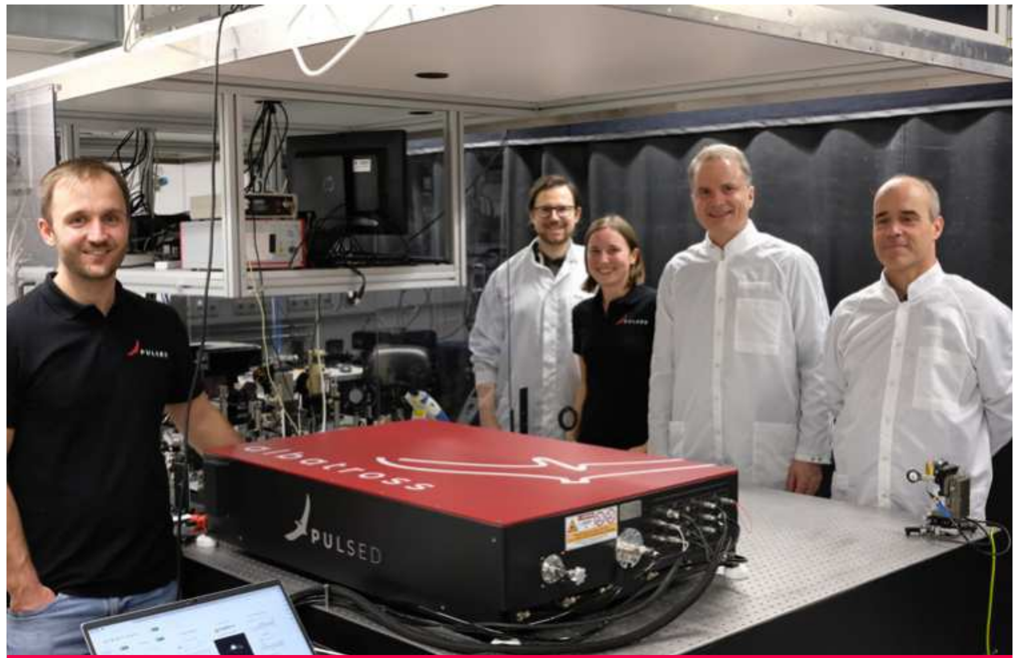
Which users are interested in your laser developments?

On the one hand, there are the groups from university research, which are primarily interested in our special laser parameters. They are targeting applications in the field of infrared spectroscopy and ultrafast laser physics. On the other hand, we have already had discussions with large companies in the field of infrared spectroscopy and laser technology. They show interest in combining our light source with existing setups from their own product range.

And we are looking at blood-based and minimally invasive health monitoring for early disease detection as a particularly promising application that

Working on the assembly of an albatross laser. Photo: Thorsten Naeser

life within attoworld



Installation of the first albatross laser at the University of Regensburg. From the left: Philipp Rosenberger, Markus Huber, Nathalie Lenke, Prof. Rupert Huber, Prof. Jascha Repp
Photo: Sebastian Gröbmeyer

is also being pursued in the ATTOWORLD-group (together with the Center for Molecular Fingerprinting). In the long term, we are targeting this market of medical applications, where we see great growth potential.

Do you have plans for the future?

We are happy that we will not run out of work in the near future! At the moment, we are well occupied processing our current orders. This will allow us to establish ourselves well in the highly competitive and constantly growing photonics market. In addition, we want to continuously expand our product range as well as our customer base by offering modular extensions to our laser system in the future. This should not only extend the spectral range and increase laser power, but also enable field-resolved spectroscopic measurements with high sensitivity.

Together with the long-term goal of opening up medical applications, we have a lot planned – both in research and in product development. To make it all happen, we are always looking for new colleagues to join us. We welcome anyone who contacts us and shows interest in working with us to accomplish these tasks! Exciting times are ahead at PULSED!

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UFI develops and manufactures a wide range of optical components, custom-made optics, and optical devices for ultra-short pulse laser applications from the IR to the XUV/soft X-ray region. To visit the UFI website, you will find a QR code at the end of the article.

celebrating Day of Photonics

or the metamorphosis of UFI's CEO Alexander G.

january 30, 2024 // Dr. Veit Ziegelmaier

The year holds two special commemorative days for laser scientists and engineers. In addition to the "International Day of Light", which is celebrated on May 16 in memory of the day in 1960 when Theodore H. Maiman succeeded in generating coherent light for the first time, the "Day of Photonics" is held on October 21. This date refers back to 1983, when the General Conference of Weights and Measures set the speed of light as a fundamental constant of nature at 299,792,458 m/s. Every year on this day, information events on photonics, the science and technology of light, are held around the world. UltraFast Innovations, a spin-off of the Ludwig-Maximilians-Universität München and the Max Planck Institute of Quantum Optics, which manufactures individual laser systems and optics for the ultrashort pulse laser range, came up with a special marketing campaign last fall. CEO Dr. Alexander Guggenmos slipped into the role of "Neo", the protagonist of the successful and legendary "The Matrix"-film series originally played by Keanu Reeves.

Choose the "ultrafast" mirror to join the ultrafast revolution. UFI's CEO Dr. Alexander Guggenmos takes on the role of the protagonist Neo from the "Matrix" film series on the occasion of the "Day of Photonics".
Photo: UFI/Thorsten Naeser, Artwork: UFI/Dennis J.K.H. Luck

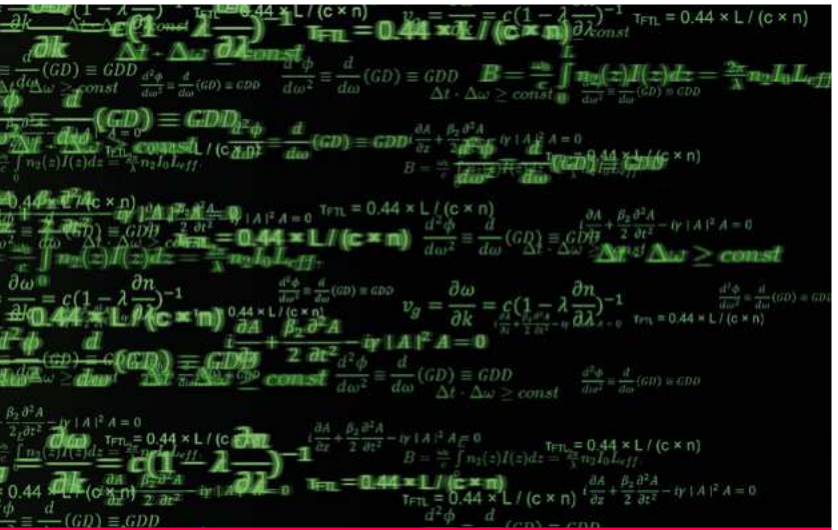
UltraFast Innovations

Who has not heard of the cult "The Matrix"-film series, which now comprises four parts and has fascinated moviegoers and film fans since 1999? And not just because of its extraordinary special effects and the now iconic green encrypted data rain of the Matrix code against a dark background. The captivating, irritating central plot moment – that life is a fake illusion – also had a lasting effect. In the very first part of this futuristic saga, the chosen protagonist Neo has to decide whether he would rather swallow the blue or red pill. With the blue medication, he returns to the perfect dream world that the Matrix has constructed for him and everything remains as it is. The red pill, on the other hand, opens his eyes to the world as it really is. It allows him to wake up from his sleep and see the unvarnished reality, the real life behind the illusory world.

If you visited UFI's LinkedIn page on October 21, 2023, you were overcome by a cinematic sense of déjà vu. In a frontal view and with deadly serious facial expressions, dressed in a long black leather coat and dark sunglasses, you were confronted with the figure of "The Matrix" title hero Neo. This time, however, he was not embodied by Keanu Reeves, but by UFI Managing Director Dr. Alexander Guggenmos, who presented two optical mirrors in a challenging manner. One in a dark grey color and one shimmering golden yellow, next to which the word "ultrafast" appears in the picture. The accompanying text below the image made reference to the aesthetics of the film used here:

Meet us in THE ULTRAFAST MATRIX!
Unleash your curiosity and become the architect of your own discoveries: choose the "ultrafast" mirror to join the ultrafast revolution. For those who are hesitant, do you really want to miss out the ultrafast experience?

Two links were available, analogous to the blue and red pill in the movie. If you wanted to stay in the familiar world, which is already perceived as fast-moving, you came to the Wikipedia entry on picoseconds, which ultrashort pulse laser scientists can only grin about. The courageous speed fanatics chose the alternative, which led to a landing page on the UFI website specially created for the "Day of Photonics". Laid out in bright poison green and using the now iconic cryptic matrix code, this portal led to the ultrafast world and thus to the range of products and services offered by the manufacturer of laser systems and optics specializing in ultrashort pulse technology. If you clicked on UFI's range of "Optical Devices", you had the impression of being taken around the globe and some of its natural phenomena. From the highest mountains of the Himalayas and Karakoram, "Everest" and "K2", countries such as "Nepal", to glaciers ("Glacier"- series), the "Tundra" and the "Savanna", but also major rivers such as "Madeira". These designations cover a total of eleven highly complex laser systems. From the soft X-ray / XUV /



Gain an insight into the "Deep Matrix" as envisioned by UFI.
Illustration: UFI / Dennis J.K.H. Luck

VUV spectrograph ("Everest") to the compact single-shot CEP-meter ("Madeira"). The latter is the latest device in the product family and was presented to an interested audience at this event. If you clicked on "Optics", there was a wide range of mirrors, two of which UFI's Neo is holding up to the viewer in the opening image.

And there was yet another option available: the full-bodied promise of being able to experience insights into the "Deep Matrix" and thus into the secrets of the universe in real time. Admittedly, a somewhat uneasy feeling creeped over you at first, as you instinctively wondered what to expect and whether we might actually be living in a dream world. And if so, how do the guys at UFI of all people know what exactly is behind it? Do they have the philosopher's stone in their vault or have they even built it? One click further and you are immersed in the "Deep Matrix" and are confronted with a collection of overlapping formulas that initially mean nothing to the layman, but certainly reveal more to the laser scientist, as these are physical equations from the field of ultrafast science.

The unusual campaign was definitely well received by UFI's followers and was liked, commented on and forwarded. But how is a marketing idea like this developed and implemented? We take a brief look behind the scenes. In the run-up to the "Day of Photonics", UFI came up with the idea of running a special marketing initiative for LinkedIn. Since CEO Dr. Alexander Guggenmos is himself a "The Matrix"-fan with a passion for film and, after a period of short hair, had let his hair grow longer again, his circle of acquaintances gave him the well-meaning suggestion that he would make a good Keanu Reeves. So the basic idea of doing something along these lines was born. But how could the whole thing be realized? A quick internet search quickly led the PR-team to the answer. A picture of the Matrix code was quickly found and an online shop had the right costume for the carnival season at a manageable cost. The next step was to go to a "green room"- studio for photo and film recordings. The advantage is that the person in front of a uniform green wall can be cropped relatively easily in digital post-production, as the computer recognizes the monochrome background surface as such by means of a so-called chrome keying effect and can filter it out. After Alexander

How it all began: Dr. Alexander Guggenmos in the green room studio.
Photo: Dr. Veit Ziegelmaier

UltraFast Innovations

had changed his clothes and struck a credible pose with coaching from the theater-savvy author of these lines, the photos were taken in front of the green wall by hired photographer Thorsten Naeser. The image material was then sent to Dennis Luck for digital image processing, who first cropped Alexander's shot and added a template of the matrix film code. A series of fine-tuning steps were then carried out. The photo was brightened a little and the color values were edited and a green glow effect was integrated, which traces the body contours in an impressive and high-contrast way. The vertical code rows of the background were also placed over the body and the sunglasses with a slight transparency, giving the impression that the figure is completely embedded in the matrix. The next step was the design and implementation of the landing page by Dennis Luck together with a web developer, in collaboration with Alexander.

Incidentally, anyone who has ever wondered how the developers of the original Matrix code for the film series came up with the trickling cryptic characters and what is actually behind them should refer to the statement by Simon Whiteley, the production designer of the encryption sequence that has become legendary. Spoiler alert!

"I like to tell everybody that The Matrix's code is made out of Japanese sushi recipes," says Whiteley, He scanned the characters from his wife's Japanese cookbooks. "Without that code, there is no Matrix." Now it's your own fault if you get a craving for raw fish at the next "The Matrix"-movie night.

Here you can visit the UFI landing page, where you will also find their products, optical devices and optics, for the ultrashort pulse range:

www.ultrafast-innovations.com/matrix

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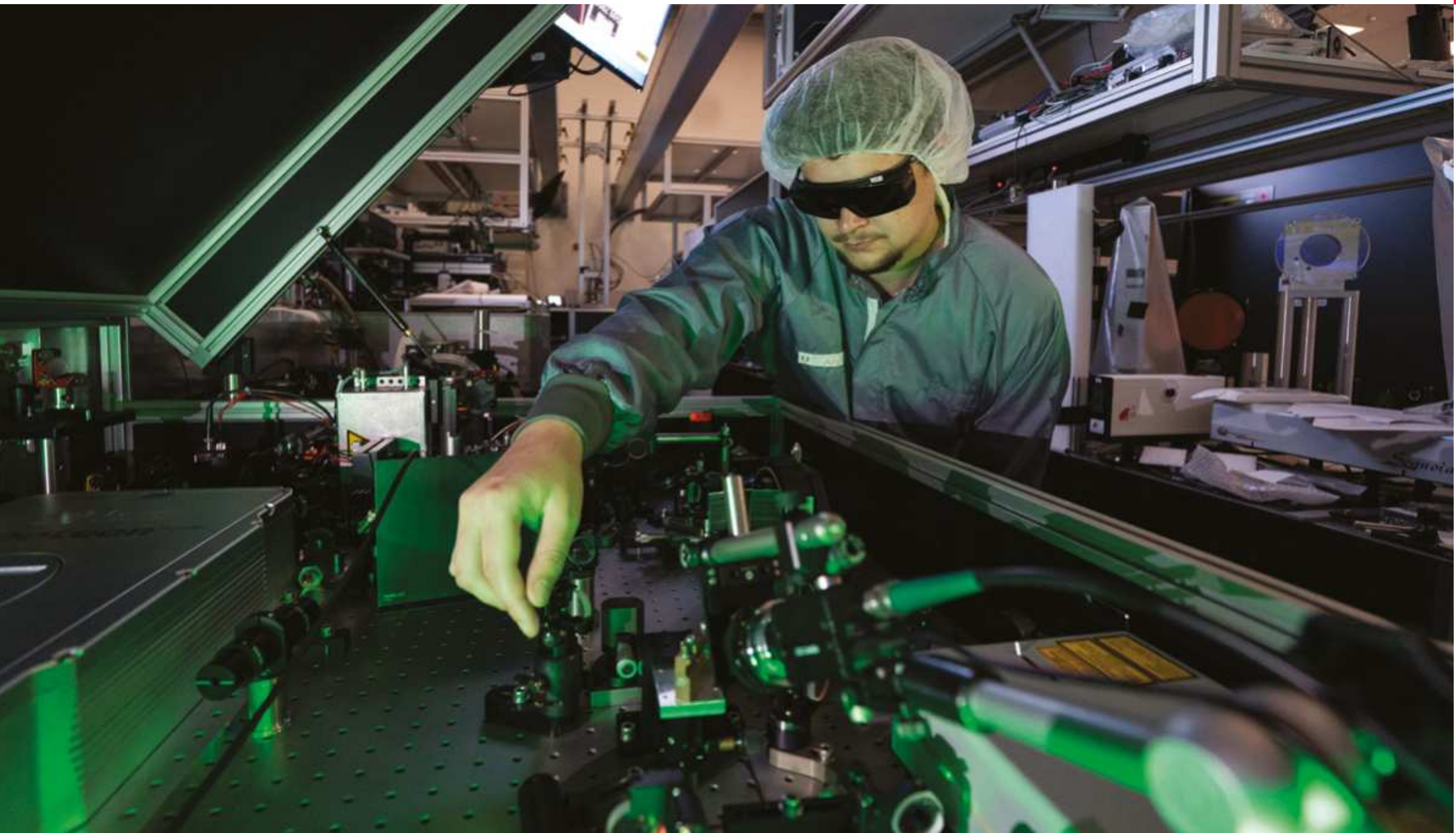
a steady progress in long-term projects

january 17, 2024 // high field lasers and applications group

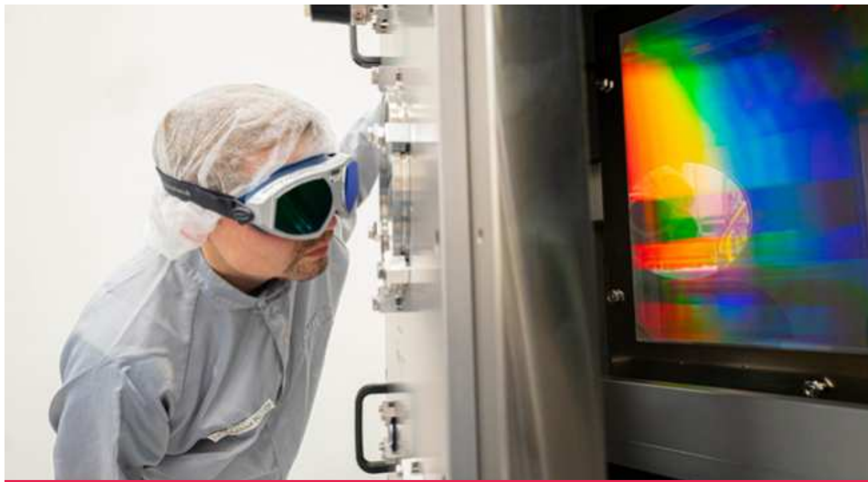
For the ‘High Field Lasers and Applications Group (HiFLAG)’, 2023 was a year of steady progress in long-term projects: ATLAS-3000 was used for 80 shot days for Experiments in ETTF. Roughly one quarter of that time was used to study multi-objective, multi-fidelity machine-learning-based strategies for optimizing the electron accelerator, which allowed to successfully maximize the spectral energy density of the electron beam for any pre-selected particle energy from 50 MeV to 350 MeV. These findings are in the process of being evaluated for publication by Phys. Rev. Letters. A novel characterization method for detecting the increasingly important spatio-temporal couplings of ultrahigh-power laser pulses has been developed and applied to ATLAS-3000 and other PW-scale laser systems, such as ELI Beamline’s L3 (Hapls) system of the PW laser at CLPU in Salamanca, resulting in a publication in ***Optics Express* 31** [1].



ATLAS-3000 was used for 80 shot days for Experiments in the Electron and Thomson Test Facility (ETTF). Roughly one quarter of that time was used to study multi-objective, multi-fidelity machine-learning-based strategies for optimizing the electron accelerator. Photo: Thorsten Naeser

research@attoworld

Tests and optimization beam time has been made available for projects such as transition radiation spectroscopy of the longitudinal electron bunch profile, transverse plasma probing optimization, detection of >100 keV X-ray beams, and GeV-scale hybrid LWFA/PWFA acceleration. All the topics are long-term oriented and therefore still work in progress. Significant progress has been made to increase the energy of monoenergetic electron beams injected via optical shock injection. A stable operating regime at 1 GeV, with bunch charges on the order of >300 pC has been identified and published in ***Scientific Reports* 13** [2]. This work was part of the effort to demonstrate non-perturbative Breit-Wheeler pair creation in the laboratory, a joint effort between LMU Munich, University of Düsseldorf and University of Jena as part of the Research unit “Probing the Frontiers of Quantum Vacuum”. Recently, with an increase of the laser power to 900TW, we were able to increase the electron energy to 2.5 GeV, the level required for the ‘Breit-Wheeler experiment’. These were the first PW-class shots on ATLAS-3000. No problems were detected at this laser performance level, such that we are on a good track to 1-PW+ daily operations early in 2024.



On PFS-pro, we are on a steep curve towards application experiments of the synchronized 1kHz, 100 mJ and 10 Hz, multi-J pulses.
Photo: Thorsten Naeser

On PFS, we are on a steep curve towards application experiments of the synchronized 1kHz, 100 mJ and 10 Hz, multi-J pulses. Two experimental campaigns in collaboration with Oxford University have been carried out in 2023 towards plasma-based modulation of the 1-ps laser pulses into a resonant pulse train for wakefield excitation as part of the kPAC/EuPRAXIA collaboration.

original publication:

[1] **measuring spatio-temporal couplings using modal spatio-spectral wavefront retrieval**
AUTHORS: N. Weiße, J. Esslinger, S. Howard, F. M. Foerster, F. Haberstroh, L. Doyle, P. Norreys, J. Schreiber, S. Karsch, A. Döpp
JOURNAL: ***Optics Express* 31**, 19733 (2023)

[2] **laser-accelerated electron beams at 1 GeV using optically-induced shock injection**
AUTHORS: K. von Grafenstein, F. M. Foerster, F. Haberstroh, D. Campbell, F. Irshad, F. C. Salgado, G. Schilling, E. Travac, N. Weiße, M. Zepf, A. Döpp, S. Karsch
JOURNAL: ***Scientific Reports* 13**, 11680 (2023)

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an in silico model for configurable molecular fingerprints

april 13, 2023 // broadband infrared diagnostics

Molecular fingerprinting via vibrational spectroscopy characterizes the chemical composition of molecularly complex media which enables the classification of phenotypes associated with biological systems. However, the interplay between factors such as biological variability, measurement noise, chemical complexity, and cohort size makes it challenging to investigate their impact on how the classification performs. Considering these factors, the BIRD group developed an in silico model which generates realistic, but configurable, molecular fingerprints. Using experimental blood-based infrared spectra from two cancer-detection applications, the researchers validated the model and subsequently adjusted model parameters to simulate diverse experimental settings, thereby yielding insights into the framework of molecular fingerprinting. Intriguingly, the model revealed substantial improvements in classifying clinically relevant phenotypes when the biological variability was reduced from a between-person to a within-person level and when the chemical complexity of the spectra was reduced. These findings quantitively demonstrate the potential benefits of personalized molecular fingerprinting and biochemical fractionation for applications in health diagnostics.

Illustration: Tarek Eissa

original publication:

limits and prospects of molecular fingerprinting for phenotyping biological systems revealed through *in silico* modeling

AUTHORS: T. Eissa, K. Kepesidis, M. Žigman & M. Huber

JOURNAL: ***Analytical Chemistry* 95 (16)**, 6523 (2023)

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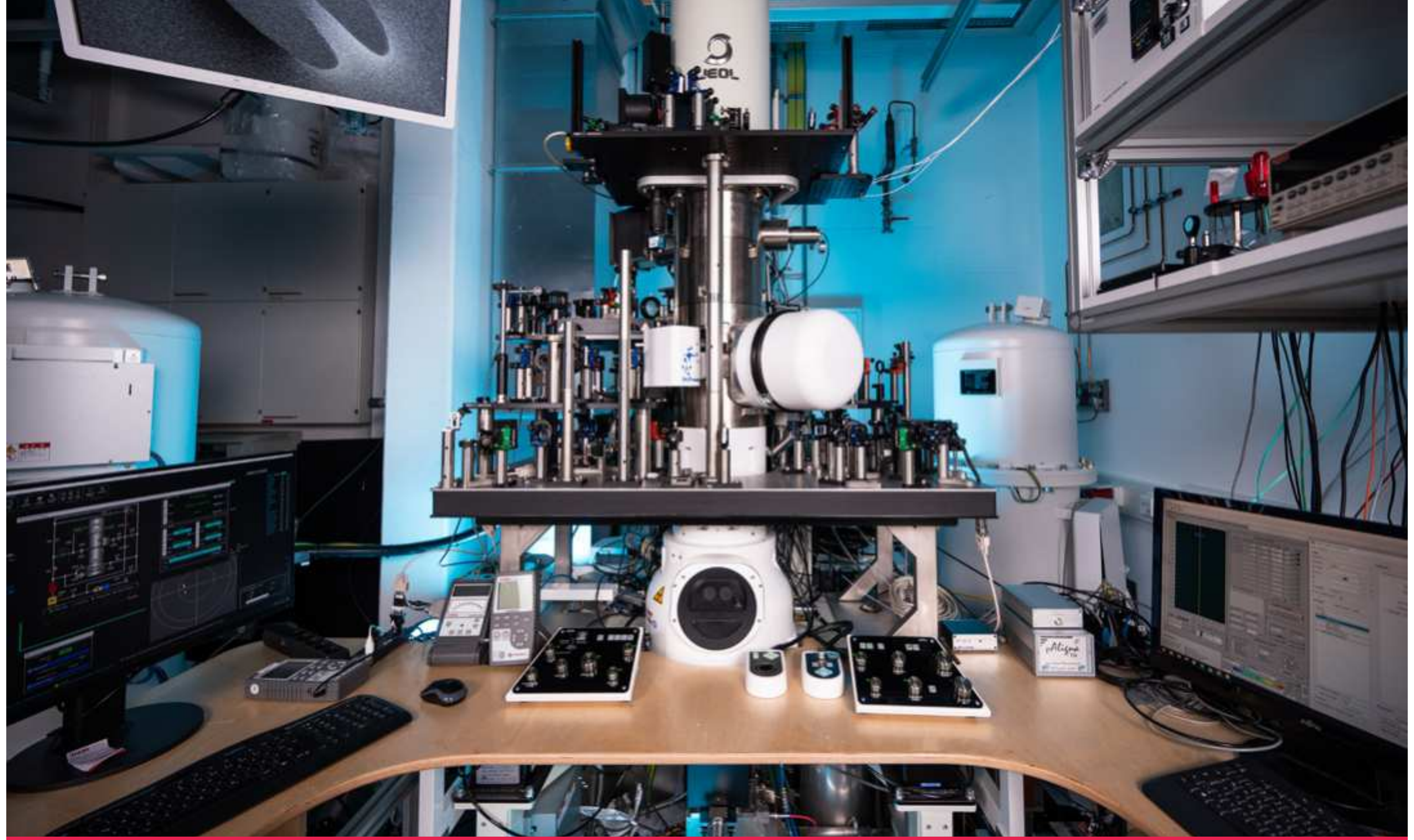

Experimental setup of the attosecond electron microscope. Photo: Dr. Gillian Kiliani / University of Konstanz

the world's fastest electron microscope

june 19, 2023 // AG Baum – light and matter

Researchers around our former colleague Prof. Peter Baum from the University Konstanz have succeeded in filming the interactions of light and matter in an electron microscope with attosecond time resolution.

Until now, it has been very difficult to directly visualize these extremely fast processes in space and time. However, the physicists from the Light and Matter Group have now succeeded in recording movies with attosecond time resolution in a transmission electron microscope, providing new insights into the functionality of nanomaterials and dielectric meta-atoms. They recently published their results in the scientific journal ***Nature***.

original publication:

attosecond electron microscopy of sub-cycle optical dynamic

AUTHORS: D. Nabben, J. Kuttruff, L. Stolz, A. Ryabov & P. Baum

JOURNAL: ***Nature* 619**, 63 (2023)

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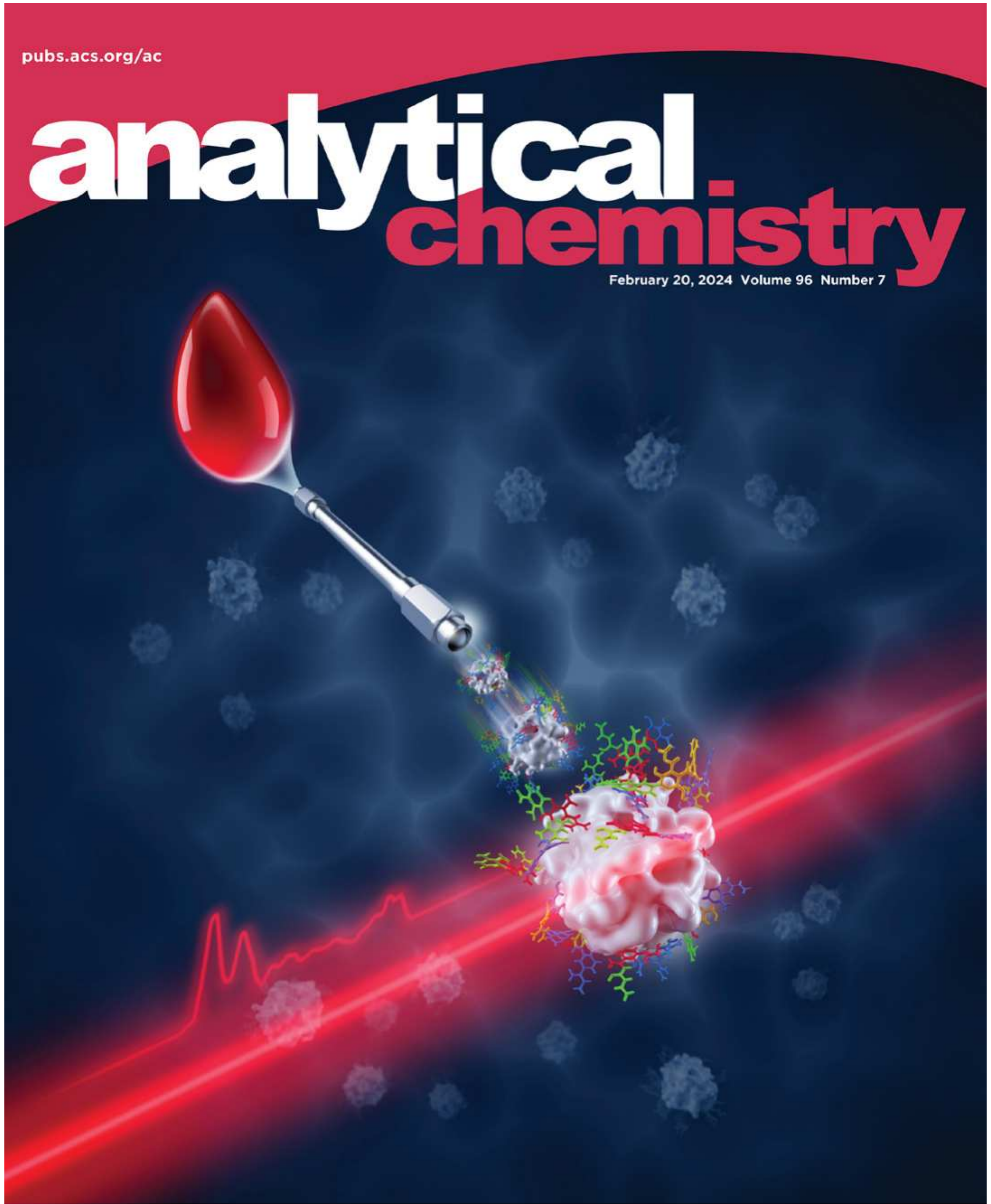

In their latest article published in Analytical Chemistry the BIRD-team observed the glycosylation patterns of blood plasma proteins using infrared spectroscopy. The scientists started from a blood plasma sample symbolized here with a drop of blood and separated the proteins therein using ion-exchange chromatography. As the fractions elute from the chromatographic column, the team recorded their infrared molecular fingerprints, which carry information about protein structure and post-translational modifications, in particular, glycosylation. The aim is to make plasma protein glycosylation analysis robust and accessible, bringing it closer to clinical applications. Cover image: Dennis J.K.H. Luck & Alexander Gelin

molecular spectroscopy zooms in on blood plasma protein modifications

february 7, 2024 // broadband infrared diagnostics

Infrared spectroscopy of blood plasma has the potential to become an experimentally simple and inexpensive way to profile the health status of an individual. However, the amount of clinical information that can be gained through infrared spectroscopy is to a large extent limited by the between-person variability and overall molecular complexity of blood plasma. In their latest study just published in Analytical Chemistry, the Broadband Infrared Diagnostics team (BIRD) steps towards circumventing both obstacles. On the one hand, the group narrowed the focus to one molecular class – blood plasma protein glycosylation. Changes in this post-translational modification are known to accompany virtually any biological process in the body, including multiple diseases. Thus, the results and conclusions are of immediate relevance to biomedical research. On the other hand, the scientists separated blood plasma proteins into individual fractions of lower molecular complexity, which can now be analysed one by one. Furthermore, in collaboration with the Bavarian Center for Biomolecular Mass Spectrometry and Genos Ltd., the team thoroughly characterized the fractions using mass-spectrometry based proteomics and glycomics. Overall, this work capitalizes on the benefits of infrared molecular fingerprinting, but uses a specific sample preparation approach to increase the amount of obtained spectral information and its interpretability, potentially leading to improved disease detection. The publication is featured on a supplementary cover in the magazine.

original publication:

probing blood plasma protein glycosylation with infrared spectroscopy
AUTHORS: L. Voronina, F. Fleischmann, J. Šimunović, C. Ludwig, M. Novokmet & M. Žigman
JOURNAL: ***Analytical Chemistry 96***, 7, 2830 (2024)

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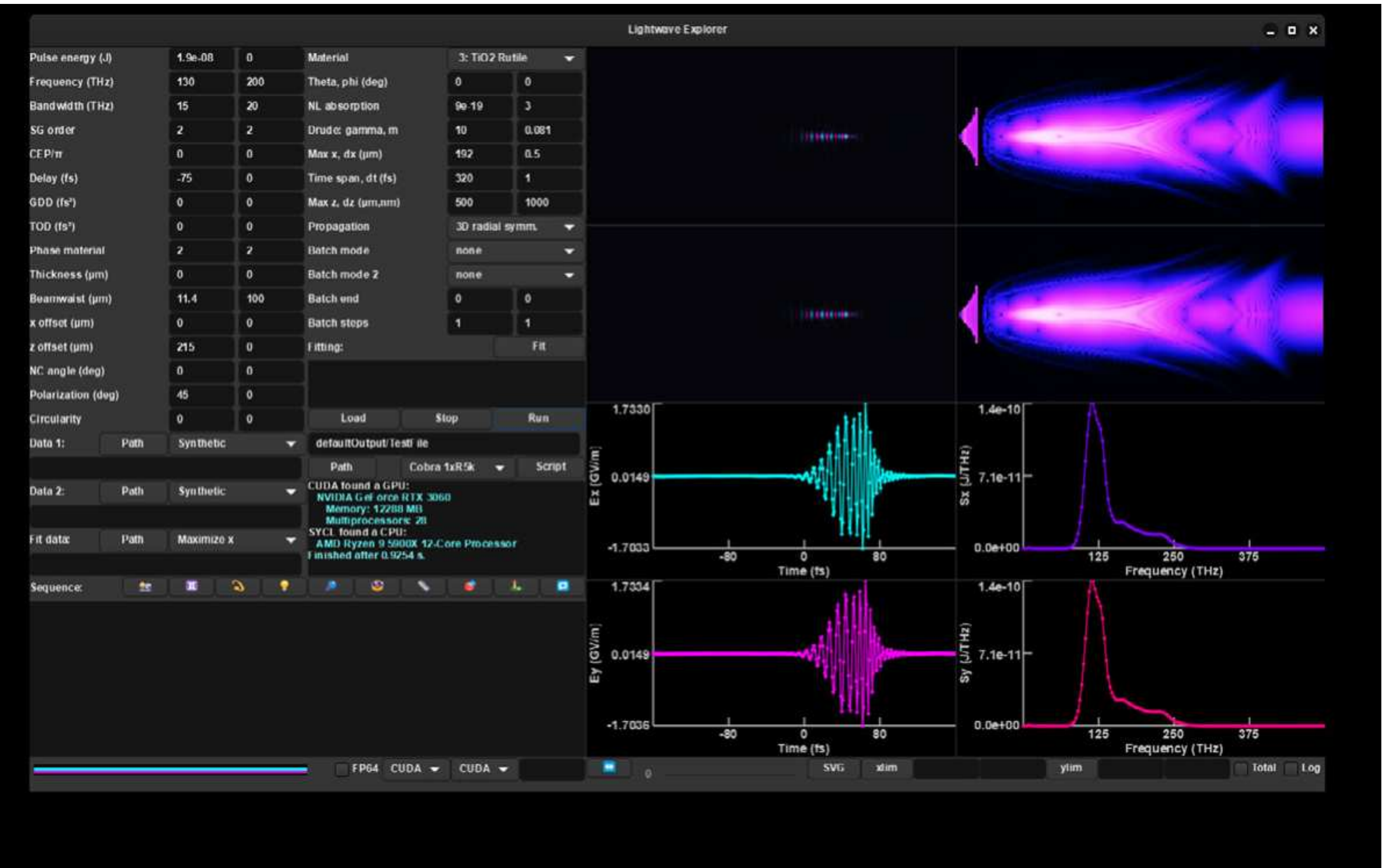
open-source nonlinear optics simulations: lightwave explorer

january 3, 2024 // attosecond spectroscopy 2.0

Our ATTOWORLD-team uses many nonlinear optical effects: this is what lets us amplify and control the bandwidth of our laser pulses, shift their frequencies into the ultraviolet or mid-infrared, and gives us sensitive ways of detecting light's electric field. Predicting what will happen in real-world applications of nonlinear optics can be complicated: the results will often depend on complicated systems of optics where what happens in one element can have unexpected consequences down the line. This requires sophisticated modeling if we're going to make accurate predictions about how these systems behave. To help with this, and to let students and other researchers across the world get a feeling for interacting with nonlinear optical systems, Nick Karpowicz of the Attosecond Spectroscopy 2.0 group wrote an open-source software package called Lightwave Explorer.



The software is both powerful and easy-to-use, giving a lot of visual feedback about the results of the simulation, and making use of modern computer hardware, including GPUs and CPUs, and it runs on Windows, Linux, and MacOS (both the source code and the executable application can be found via the QR code at the end of the article).

The code has been released as an open source project for several reasons: Since the inner workings of the simulation are available to the public, there are no secrets regarding our understanding of our experiments, in-line with the principles of Open Science, which aims to democratize access to scientific data and improve reproducibility of results. Performing numerical experiments is a great way to learn the inner life of light-matter interaction; making it freely available and accessible allows students all over to get a chance to play with and learn about nonlinear optical systems, even without access to a laser. And it also allows other scientists to contribute directly to the codebase – incorporating ideas and data from other researchers to improve and extend our capabilities together.

The code has already been used to reproduce experiments in a number of recent publications, which are listed at the end of the article.

With these efforts the ATTOWORLD-team is making a big step into the world of open source science, and we hope that research in the coming years is more open, and more welcoming to those without the resources we are lucky to have.

publications:

ultra-CEP-stable single-cycle pulses at 2.2 µm
AUTHORS: M. Kowalczyk et al.
JOURNAL: ***Optica* 10**, 801 (2023)

broadband photoconductive sampling in gallium phosphide
AUTHORS: N. Altwaijry et al.
JOURNAL: ***Advanced Optical Materials* 11**, 2202994 (2023)

in-line synthesis of multi-octave phase-stable infrared light
AUTHORS: H. Kassab et al.
JOURNAL: ***Optics Express* 31**, 24862 (2023)

a paper about the simulation itself has also been recently published:

open source, heterogeneous, nonlinear optics simulation
AUTHORS: N. Karpowicz
JOURNAL: ***Optics Continuum* 2**, 2244 (2023)

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http://github.com/NickKarpowicz/LightwaveExplorer

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ultra-CEP-stable single-cycle pulses at 2.2 µm

june 22, 2023 // field-resolved infrared spectroscopy

The ATTOWORLD-team dedicated to field-resolved infrared spectroscopy has developed a new Cr:ZnS laser oscillator providing ultra-stable single-cycle pulses at 2.2 µm center wavelength. The research was featured on the cover of June's edition of the journal Optica. The illustration shows the compression of a 2.2 µm pulse to single-cycle duration by extreme spectral broadening in a titanium dioxide (rutile) plate. Laser pulses carrying only a single cycle of the electric light-field allow to manipulate electron motion and nonlinear processes in matter on the inherent, sub-femtosecond time scales of the electric-field evolution. Previous single-cycle sources were typically based on kHz-rate Ti:sapphire lasers emitting at 800 nm center wavelength. With the new ultra-stable laser system the scientists are able to generate pulses of single-cycle duration at 2.2 µm and 22.9 MHz repetition rate with extremely high reproducibility. Such long-wavelength, single-cycle pulses open new possibilities for efficient frequency-conversion processes and the interaction with low-bandgap materials.

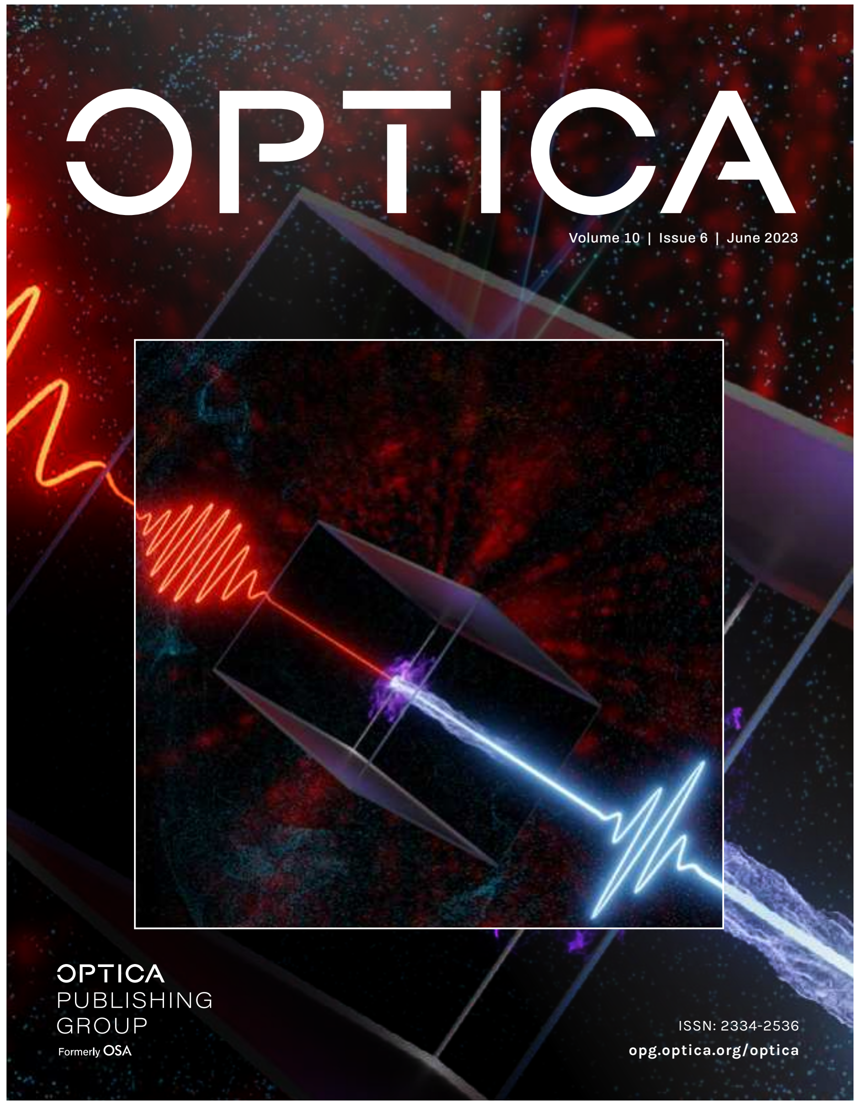

Illustration: R.MT.Bergues

The new laser system is based on a low-noise, diode-pumped laser oscillator with Cr:ZnS as the gain medium. Nonlinear optical simulations (software package available under https://github.com/NickKarpowicz/LightwaveExplorer) provided insight into the remarkable compression process in titanium dioxide, as artistically captured by the illustration: the incoming beam experiences strong self-focusing, leading in an interplay with plasma formation to filament-like propagation through the crystal. This effect maintains the beam at a small diameter and high intensity over several hundred micrometers distance. As a result, the pulses are subject to strong self-phase modulation and self-compression, leading to the exceptional spectral broadening to super-octave bandwidth that allows to generate the single-cycle output pulses. When approaching such short pulse durations, it becomes essential to control the phase of the light field under the pulse envelope (carrier envelope phase, CEP). In collaboration with Wrocław University of Science and Technology the scientists could lock the CEP of the output pulses with a record-low residual jitter of only 5.9 mrad, ensuring that the emitted single-cycle electric-field waveforms are highly reproducible from one laser shot to the next. The unique laser source will be the basis for the next-generation field-resolved infrared spectrometer that is currently under development.

original publication:

ultra-CEP-stable single-cycle pulses at 2.2 µm

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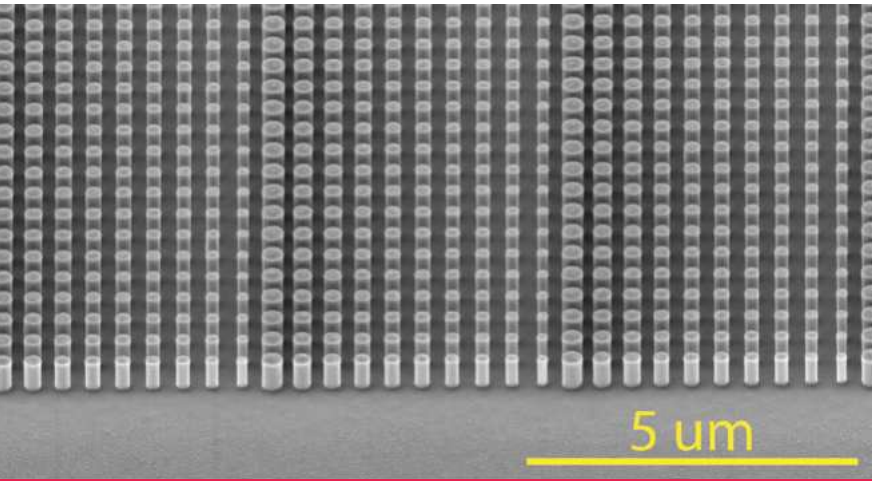
it's a match optical – metasurfaces and ultrafast science

january 17, 2024 // asst. Prof. Marcus Ossiander

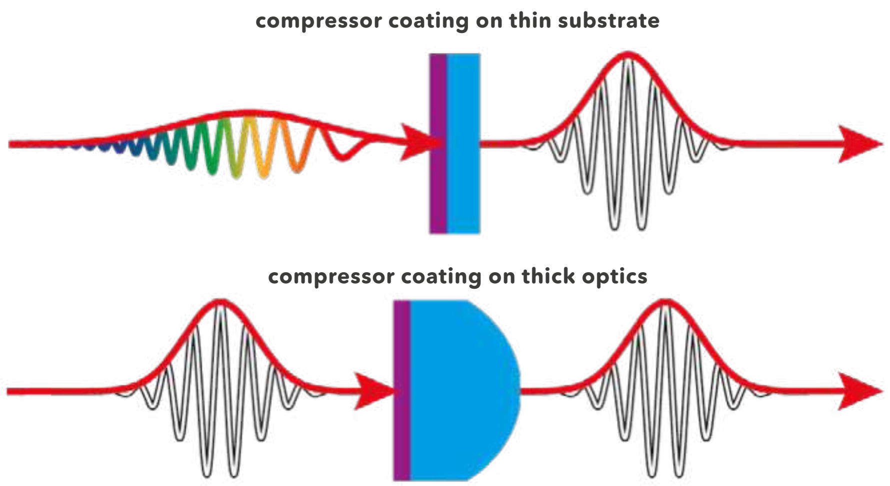
Catapulted by the increasing availability of nanofabrication, optical metasurfaces are revolutionizing applied optics by combining the best from Fresnel lenses, phased arrays, waveguides, and Mie scattering. To manufacture a metaoptics – instead of molding, grinding, and polishing glass – Marcus Ossiander, Assistant Professor, Graz University of Technology / Harvard University and his team arrange an ensemble of miniscule structures, e.g., pillars, made from high refractive index materials such as silicon or titania on an entirely flat substrate.



Visible Light Metasurface. Titania sub-wavelength nanopillars modulate the phase of transmitted light. The function of the macroscopic optics arises from the arrangement and shape of the nanopillars. This example combines an axicon with a focusing lens.
Figure 1: TU Graz / M. Ossiander

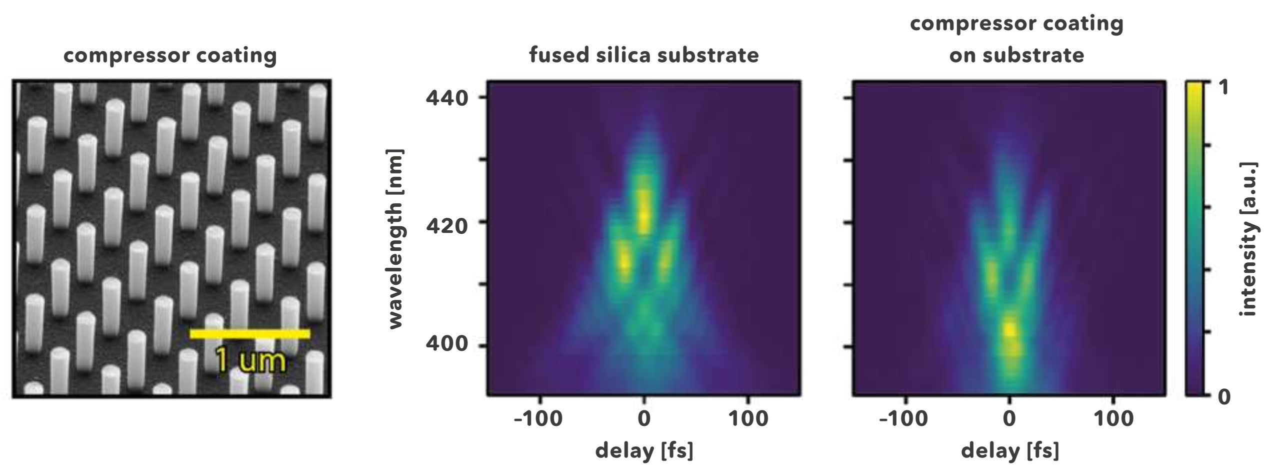
As long as two adjacent nanostructures are spaced by less than the wavelength of the light, an incoming light wave experiences the structure ensemble as a slowly changing material rather than many individual structures. Consequently, metaoptics (although similar in appearance to two-dimensional gratings) can manipulate the phase of light on the nanoscale without creating unwanted diffraction orders that diminish efficiency. Even better, when using rectangular structures, metaoptics can also change the light's polarization locally. These new capabilities have quickly redefined the state of the art in structured light.

Because diffractive optics naturally suffer from chromatic aberrations, metaoptics were initially not considered broadband optics and thus not considered for ultrafast laser pulses. However, scientists soon realized that metasurfaces can introduce optical resonances locally. When chosen correctly, such resonances can introduce a designed, wavelength-dependent, phase shift – the spectral-domain equivalent of a controlled group delay and group delay dispersion. This capability allows defeating chromaticity across the visible spectrum and replacing complex achromatic multi-lens systems with a single flat optics [1, 2]. The other consequence of this development was that metasurfaces are fit for ultrafast laser pulses – but now we knew it. Thus, I moved from working with the world's ultrafastest lasers at attoworld to Federico Capasso's group to explore this new technology's potential.



Concept of a compressor coating: the violet metamaterial coating possesses negative group delay dispersion; glass has positive group delay dispersion. When combining the coating with a thin substrate, its dispersion exceeds that of the substrate, resulting in an overall negative dispersion that can compensate for other optical components. When placed on a thicker optics such as a lens, their dispersions cancel, allowing the application of the compound to ultrafast laser pulses. Figure 2: TU Graz / M. Ossiander

A first application was quickly identified after years of meticulously counting every millimeter of glass in the laser beam: creating dispersion-less glass would finally allow the use of transmissive optics without lengthening ultrashort laser pulses [3]. Whereas nature only provides materials that imprint positive group delay dispersion onto visible laser pulses, we can create metamaterials with negative group delay dispersion. We achieve this by composing the material from nanostructures that exhibit a scattering resonance at a lower frequency than the laser pulse we want to use it for. When put on an optical component made from glass, e.g., a beam splitter or a lens, their dispersion should cancel, resulting in an ultrafast-pulse-ready optics. One challenge remained: just as a naturally occurring material, a metamaterial reflects light close to resonance, defeating the purpose of a transmissive beam compressor coating. However, we can manipulate metamaterials to also behave like antireflection coatings: we achieved this by using nanostructures that possess a second resonance close to the first resonance and choosing its properties such that the light reflected by both interferes destructively [4].



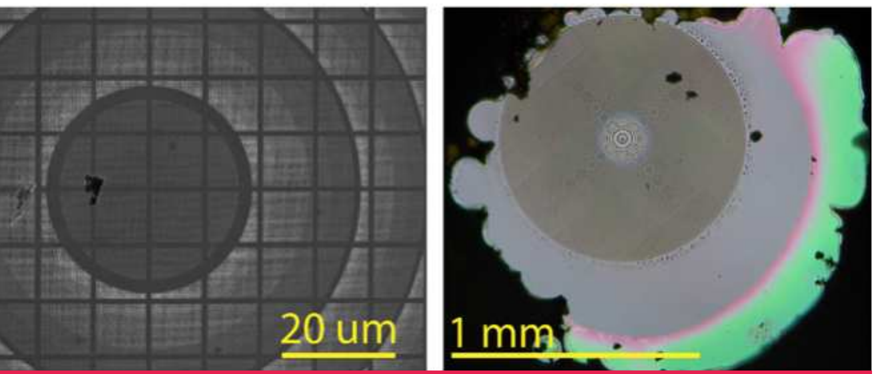
Realization of a compressor coating. Left: a metamaterial manufactured to compress ultrafast titanium-sapphire laser pulses. Right: FROG measurements of a laser pulse transmitted through a bare glass substrate and the same substrate with the coating applied show a pulse compression from 48 to 37 femtoseconds. Figure 3: TU Graz / M. Ossiander

After completing the design, my colleagues at Harvard manufactured the compressor coating from silicon nanopillars. Then, Martin Schultze's group characterized the finished sample at TU Graz. The nanocoating was a success: it turned out roughly 3.000 times more dispersive than glass, meaning the 600-nm thick nanocoating can compensate up to 2 mm of fused silica and works for pulse durations down to 10 femtoseconds.

An even steeper challenge from the field of attosecond physics remained: high-harmonic generation creates the shortest available light pulses in the extreme ultraviolet spectrum. In fundamental science, these have developed into an indispensable tool to explore electron dynamics in atoms and solids. In technology, extreme ultraviolet light is the central ingredient to upholding Moore's law. Unfortunately, there are very few optics for extreme ultraviolet radiation because all materials strongly absorb such light.

Metasurfaces –often thousands of times thinner than classic optics– seem predestined to solve this absorption issue. However, metasurfaces usually comprise nanostructures with high refractive indexes that mold the phase of transmitted light. High refractive indexes do not exist in the extreme ultraviolet spectrum. On the contrary – if refractive indexes deviate considerably from unity in the extreme ultraviolet, they are usually smaller than one. For example, silicon has a refractive index of 0.88 at 50 nm wavelength. This fact allows us to create metasurfaces after switching the design paradigm: a vacuum always has a refractive index of one. When we surround it with silicon, the vacuum behaves like the high-refractive index nanopillars we are used to [5].

Thus, by etching nano-sized holes in a thin silicon membrane, we can create arbitrary spatial phase profiles. To demonstrate the concept, we designed a transmissive lens with a 10 mm focal length for 50 nm wavelength light. Because of the small wavelength, the lens contains holes with diameters down to 20 nm, a challenging fabrication even for my colleagues in Federico Capasso's group. After a year of recipe development, we achieved a promising sample.



A transmissive extreme ultraviolet metalens. Left: scanning electron microscope picture of the lens center. Right: light microscope picture of the entire lens comprising 500 million holes.
Figure 4: TU Graz / M. Ossiander

In the meantime, Martin Schultze's group had purpose-built a high-harmonic source and characterization setup for the metalens. We put the sample in the beam and saw focusing – the proof that the lens works. Because even this first sample had a higher numerical aperture than almost all existing optics in the extreme ultraviolet, we resorted to a knife-edge scan to check the focal spot. The result positively surprised us: the first sample already achieved a 700 nm focus – only 1.5 times the diffraction limit.

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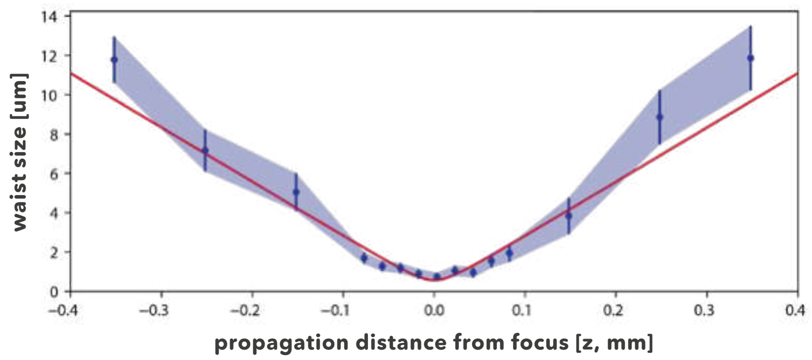

Focusing performance of the first extreme ultraviolet metalens (50 nm wavelength, 10 mm focal length).
Figure 5: TU Graz / M. Ossiander

We are starting the next chapter excited to explore which new paths this technology can enable, both in fundamental science and technology. We are looking into creating holograms, orbital angular momentum plates, and using metalenses to create a microscope for attosecond pulses. Regarding the latter: heartfelt congratulations, Ferenc.

original publication:

[1] **controlling the sign of chromatic dispersion in diffractive optics with dielectric metasurfaces**
AUTHORS: E. Arbabi, A. Arbabi, S. M. Kamali, Y. Horie & A. Faraon
JOURNAL: ***Optica* 4**, 625 (2017)

[2] **a broadband achromatic metalens for focusing and imaging in the visible**
AUTHORS: W. T. Chen, A. Y. Zhu, V. Sanjeev, M. Khorasaninejad, Z. Shi, E. Lee & F. Capasso
JOURNAL: ***Nature Nanotechnology* 13**, 220–226 (2018)

[3] **slow light nanocoatings for ultrashort pulse compression**
AUTHORS: M. Ossiander, Y.-W. Huang, W. T. Chen, Z. Wang, X. Yin, Y. A. Ibrahim, M. Schultze & F. Capasso
JOURNAL: ***Nature Communications* 12**, 6518 (2021)

[4] **high-efficiency dielectric Huygens' surfaces**
AUTHORS: M. Decker, I. Staude, M. Falkner, J. Dominguez, D. N. Neshev, I. Brener, T. Pertsch & Y. S. Kivshar
JOURNAL: ***Advanced Optical Materials* 3**, 813–820 (2015)

[5] **extreme ultraviolet metalens by vacuum guiding**
AUTHORS: M. Ossiander, M. L. Meretska, H. K. Hampel, S. W. D. Lim, N. Knefz, T. Jauk, F. Capasso & M. Schultze
JOURNAL: ***Science* 380**, 59–63 (2023)

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graduations

we congratulate all the newly qualified doctors on successfully passing their PhD exams:

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february 6, 2024 // boradband infrared diagnostics

"Rapid electric-field molecular fingerprinting – Advancing infrared laser spectroscopy for blood-based phenotype diagnostics"

Dr. Hadil Kassab

september 28, 2023 // attoworld

"In-line synthesis of multi-octave phase-stable infrared waveforms"

Dr. Maximilian Seeger

september 11, 2023 // field-resolved nano spectroscopy

"Development of High Power CEP-Stable Light Sources"

Dr. Sambit Mitra

june 22, 2023 // field-resolved nano spectroscopy

"Strong-field physics in tailored light"

Dr. Najd Altwaijry

june 5, 2023 // attosecond spectroscopy 2.0

"Pushing the boundaries of photoconductive sampling in solids"

Photos: attoworld-team

Dr. Daniel Gerz

may 2, 2023 // attoworld

"Field-resolved infrared spectroscopy based on thulium fiber laser technology"

Dr. Philipp Rosenberger

february 14, 2023 // field-resolved nano spectroscopy

"Reaction Nanoscopy: From near-field dependent ion yields toward surface chemistry"

Center for Molecular Fingerprinting

CMF is an interdisciplinary nonprofit research institution. We are an international team of medical doctors, nurses, technicians, laser physicists, electrical engineers, molecular biologists, and computer and data scientists, driven by a common goal: shaping the future of healthcare.

monitoring the health of a population with the help of laserlight

january 30, 2024 // Dr. Zoltán Kovács & Dr. Domokos Gerő

How effective and affordable could infrared electric-field molecular fingerprinting be as a medical test for monitoring the health of a population? That is what the scientists at the Center for Molecular Fingerprinting (CMF) are investigating in their flagship medical research program "Health for Hungary – Hungary for Health" (H4H). Here Dr. Zoltán Kovács, the Chief Clinical Research manager, and Dr. Domokos Gerő, the Medical Scientist, report about their plans and aims.

Our goal is to develop and verify a new way of measuring human health – an approach called infrared molecular fingerprinting. We aim to establish a way of analyzing human blood plasma with newly developed laser-based technology, characterize and monitor health, and detect possible early signs of developing diseases. Individuals will be followed over time to be able to measure and monitor the onset of possible diseases in a sensitive way, with personalized differences being measured. The target of our approach in the H4H clinical study is to evaluate whether infrared molecular fingerprinting is able to contribute to more reliable health monitoring system that shall improve quality of life for all of us.

How does the clinical research work?

Thanks to the advancement of medicine and technology, many diseases can now be diagnosed and treated very effectively, thus lengthening the time people spend in good health. However, there is a well-defined need for continuous development of even more specific and sensitive diagnostic methods and therapies; and as in sports, there is always room for improvement, especially against the backdrop of an ageing population.

Abhijit Maity performs final checks on the recently upgraded Infrasampler 1.5 system before it is transported to the new CMF laboratory in Szeged. After reinstallation, it will be used to determine the electric-field molecular fingerprint of thousands of H4H samples. Photo: Thorsten Naeser

LASER PHYSICS
FOR HEALTH

In the history of humankind, there are several written sources of controlled clinical-like trials, the first of them being probably the experiment of the ruler of Babylon, King Nebuchadnezzar, somewhere around 600 BC. This is described in the Book of Daniel in The Bible, when due to opposition of some Israeli captives to eat non-kosher food a ten-day trial was carried out which proved that a diet of legumes and water was just as good for you as eating meat and wine (which was at the time considered the best way to stay in good physical condition). As a result, the captives could stick to their meal preferences.

A long road from this story leads to today's GCP (Good Clinical Practice) era, in which clinical trials are being performed based on standardized rules and ethical considerations. All medications and medical devices must undergo a series of preclinical studies before being tested on humans. They can then be tested on human samples in the framework of clinical trials approved by ethical committees. Only once the various phases of clinical research have been successfully completed can any medication or device be marketed, and then only for the purpose it has been proven to be useful for.

[1] Collier R. Legumes, lemons and streptomycin: A short history of the clinical trial. CMAJ. 2009; 180:23–24

There are several key participants in each clinical trial, including the Sponsor of the trial, who defines the aim and hypotheses of the study; the regulatory authorities and ethics committees, who safeguard the rights of the subjects and future patients; the investigators together with the designated investigational team of doctors, nurses, and coordinators, who perform the trials at their investigational centers with outreach to appropriate subjects and necessary logistics; and most importantly the volunteers, who are either healthy or diseased subjects who offer their time and bodies to undergo the procedures described in the trial protocol. A team of clinical research professionals and their operative support helps to get everything done according to legislation, rules, and protocol. They also make sure all procedures and documents are verified so the data that has been collected can lead to a scientific conclusion.

It is crucial that a successful clinical trial is not aimed at leading to a definitively positive result for Sponsor. Rather, it needs to prove a viable idea that it can be used clinically, but no less importantly, if the idea is not viable, it must be allowed to lead to a negative conclusion, or suggest necessary changes.

What is the rationale of the H4H Program?

In 2021, CMF started its first clinical research study in Hungary, called the "Health for Hungary – Hungary for Health" Clinical Study. It is a longitudinal clinical study specifically designed to promote the applications of molecular fingerprinting into clinical translation, particularly for population health monitoring.

In our society, a large portion of deaths are attributable to preventable diseases, and these diseases also cause the people affected by them to become physically limited and even disabled. Early diagnosis and proper treatment of conditions that are precursors to serious illness are believed to serve as major contributors to prevention strategies and help reduce the burden of morbidity. However, most available medical tests are not ideally suited for health monitoring: they were developed to detect symptomatic diseases and have been secondarily adapted for applications in health monitoring: to follow up healthy individuals with the aim of recognizing the early signs of abnormalities in pre-symptomatic subjects.

Photo: Thorsten Naeser

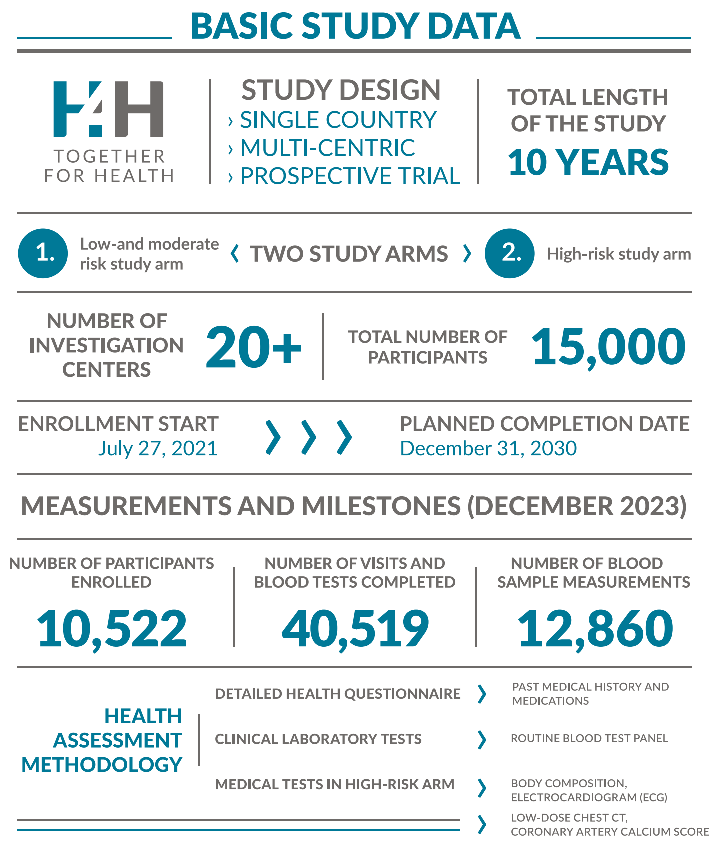
Electric field-resolved molecular fingerprinting (EMF) represents a new technological platform that allows the detection of molecules in minute concentrations that was not possible in the past. The detection sensitivity of the methodology, in combination with the speed at which the measurement device collects data, opens up new horizons in the field of medical diagnostics and *in vitro* blood tests, and may serve as a valuable tool for health monitoring in the future.

Center for Molecular Fingerprinting

The H4H Program is a prerequisite for streamlining the move of this new technology into clinical use. Since EMF and the way we analyze the data we collect presents a new approach, a normal range of measured infrared fingerprints and their possible deviations over time needs to be established before it can be used for detecting diseases in practice. Once a reference range has been established, deviation from the normal healthy state may serve as an indicator of health abnormalities and a sign of early-stage disease, even in the absence of clinical symptoms.

What are the goals of the H4H Program?

In order to develop EMF as a novel *in vitro* diagnostic tool, from concept to testing its clinical utility, in the H4H Program we are pursuing the following goals: *1) Establish the healthy baseline of blood-based infrared molecular fingerprints. 2) Establish clinical decision limits of EMF that are diagnostic for early-stage development of select non-communicable diseases (NCDs), including lung cancer, cardiovascular disease (CVD) and diabetes mellitus.*



Ad. 1. A reference interval is usually defined as the 95% confidence interval of measurement values for a healthy (reference) population, which is based on the between-subject variability of laboratory test results. As blood plasma constituents are known to vary with age, gender and other parameters such as smoking and obesity (assessed as body mass index, BMI), we foresee specific reference ranges for each of these healthy adult sub-populations (e.g., age-group specific reference intervals). Alternatively, temporal trajectories of EMF will be determined as normal patterns that develop with age and that are typical of the predefined subpopulations. These allow the prediction of expected values for a given age.

We also presume that a person-specific normal range of EMF is of considerable practical use, reflecting very little variation in individuals over time. The low within-subject variability may allow for an even narrower, individualized normal range that may prove more appropriate for detecting early-stage health deviations.

Establishing a reference range of infrared molecular fingerprints and its deviations, based on a healthy population, may initially seem of limited clinical use, though, as it is very much specific to health, and this information may not be directly transposed to the likelihood of disease: test results outside the reference range may not indicate a disease. Yet, it will have significant impact for the second milestone.

Ad. 2. The ultimate goal of novel diagnostics is to aid clinical decision making. Therefore, it is important to establish clinical decision limits: diagnostic results criteria that can be used in clinical medicine to make decisions, i.e., proceed with diagnostic tests (e.g., imaging methods), decide on an intervention, or choose a treatment modality. This aim will be best fulfilled if the criteria are supported by evidence of disease or are based on clinical outcomes. If a symptomatic clinical disease is present, selecting individuals with a well-defined condition, specific outcomes may be chosen for setting up clinical decision limits (e.g., diabetic individuals are followed up for the development of complications). However, the association between specific medical test results and the presence of disease is more difficult if symptomatic disease develops years later in seemingly healthy people. For these conditions (i.e., lung cancer and CVD) follow-up is needed until the diagnosis is given.

In the framework of the H4H Program, to evaluate the feasibility of EMF for health monitoring, individuals are followed for up to ten years. Blood plasma collection and analysis are continued throughout the observation period and the development of clinical disease is noted to precisely record the time of diagnosis to help validate EMF data.

Another milestone for CMF and the Hungarian H4H study: After six months of intensive construction, the team from attoworld's FRIS (Field Resolved Infrared Spectroscopy) research group and CMF's Laser Science department completed the Infrasampler 1.5 for future operation in Hungary at the start of the new year. The highly complex, large-scale laser system will be used to measure the molecular fingerprint in the blood samples of the Hungarian H4H study initiated by CMF for the early detection of serious diseases such as cancer. Here you can see the progress of the installation in the CMF laboratories in Szeged, which began at the end of January 2024. Photos: attoworld-team

How is the H4H Program organized to pursue these goals?

In the framework of the H4H Program, we collect blood samples from 15,000 healthy volunteers over a 10-year period. To achieve these objectives, the H4H Program is running at more than twenty investigational centers under the guidance of CMF, with the involvement of 5–15 team members at each of the centers. A lot of healthy participants are required to set up age-group and gender-specific reference ranges, and a long follow-up period is necessary to observe the development of diseases, due to the relatively low incidence of events.

Participants are enrolled into two arms of the study: (1) a low- and moderate-risk cohort and (2) a high-risk cohort of subjects, corresponding to the risk of cardiovascular disease development. In the low- and moderate-risk cohort follow-up is foreseen for ten years, while the sample collection period is expected to run for five years in high-risk individuals. The two cohorts are expected to provide complimentary information: the low- and moderate-risk cohort will be superior in establishing the population reference intervals, and the high-risk cohort will provide the bulk of disease-specific signals. Personalized reference ranges will be determined in all participants, and disease development is expected in both cohorts. We expect that approximately 400 fatal or non-fatal CVD events may occur in the low- and moderate-risk cohort over ten years, and around twentyfive cases of lung cancer will be detected. The high-risk cohort participants are older subjects and thus the risk of lung cancer is considerably higher. Therefore, hundred newly diagnosed lung cancer cases are foreseen on this arm of the study within five years. Also, the relative frequency of CVD will be higher on this study arm but this is counterbalanced by the shorter observation period. Type 2 diabetes mellitus prevalence is around 10% in subjects enrolled in the study thus far, allowing us to study the actual development of diabetic complications with sufficient prevalence for subsequent data analysis over the given observation period.

All subjects are followed up with between one and three visits a year, during which health data is collected, clinical laboratory blood tests are performed, and plasma samples are collected for EMF measurements. Samples are transferred to deep frozen storage temperature (–80 °C) within three hours of blood draw and are transferred to CMF's designated biorepository for long-term cryopreservation. High-risk individuals will undergo additional medical imaging tests and medical screens to check for cardiovascular disease and lung cancer to verify the health status of subjects.

What makes the H4H Program unique both in Hungary and internationally?

The H4H Program is a cutting-edge research study with a longitudinal prospective design that is not comparable to any prior clinical trials conducted in Hungary before. As part of this daring project, we have built up a trusted network consortium of clinical centers and involved more than 10,000 subjects in the study in less than a year and a half, with the prospect of further 5,000 participants to be recruited in the upcoming year. Regarding the scale of the clinical study, this number is near equal to the total number of subjects being enrolled in all therapeutic interventional clinical trials ongoing across Hungary; and it is highly representative of the population, also functioning as an observational study: corresponding to 0.2–0.3% of all middle-aged and elderly people in Hungary. Since all health data is carefully checked by clinical monitors, and any incongruences are corrected according to the original clinical records, the data quality of H4H Program is superior to typical observational studies, showing a close resemblance to interventional drug trials in this respect.

Moreover, the H4H Program is an exceptional endeavor due to several factors all over the world, and not only in Hungary. The study aims to facilitate the clinical translation of a novel health monitoring medical test that is not based on disease-specific markers but on the entirety of molecules dissolved in human blood plasma, as a biomarker-agnostic, holistic approach. EMF allows the detection and analysis of unknown constituents of the plasma, unlike other methods that only focus on already known proteins, nucleic acids or metabolites. This means it may be able to identify novel tumor associated fusion-proteins that could change the future of diagnostic medicine.

While the approach detailed above is expected to provide positive results, the study incorporates two inherent fallback strategies, which sets it apart from similar studies: (1) the possibility for retrospective (re-) analysis of samples and (2) an option for expanding the study with additional high-content diagnostics. As opposed to the prospective design, the former approach lets us re-evaluate the disease-specific spectral patterns and makes it possible to identify additional spectral markers after the respective conditions have been diagnosed. The second option is a feasible expansion of the study to optimize early disease detection: cryopreserved plasma may be re-analyzed in the future either by a more advanced molecular fingerprint analyzer or using any omic methods (e.g., mass spectrometry-based proteomics, glycomics or metabolomics) that supplement the acquired data to provide a more complete health assessment methodology.

Photos: attoworld-team

Overall, the H4H Program has already delivered some very positive effects for the participants, but there is still a long way to go to achieve the final goals of the program. Given the recurrent routine laboratory testing and regular check-ups by medical professionals, many subjects have been made aware of several already underlying conditions they did not know about. Also, the risk of disease was uncovered in some subjects in cases in which a condition was not adequately suppressed by the applied therapy (e.g., high cholesterol level despite receiving lipid-lowering treatment). As a result, treatment initiation or adjustments were recommended for some of the enrolled subjects that will potentially lead to longer life expectancy and a better life quality.

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art & science

light unlimited: "no object, no image, no point of focus."

James Turrell's light art installation at DIMU Freising

february 6, 2024 // Dr. Veit Ziegelmaier

Light is life. It fascinates and magically attracts us. As light at the end of a tunnel, it becomes a symbol of hope and is associated with ideas of the afterlife. However, you can already experience in this world what it is like to immerse yourself in a seemingly boundless space of light. And not far from where our ATTOWORLD-laboratories are located. The newly designed Diözesanmuseum on the Domberg in Freising makes this experience possible in a unique light installation by the internationally renowned contemporary artist James Turrell.

Due to an unanswered request for reproduction rights, our author decided to depict his impressions of his visit to the light installation as watercolors afterwards. This gives the visitor a similar impression of the play of colors within the chapel designed by James Turrell.
Watercolors: Dr. Veit Ziegelmaier

Following a comprehensive renovation, the Diözesanmuseum Freising opened its doors in a completely new look in October 2022 after nine years of restoration work. In the process, the DIMU, as the institution is now known for short, pulled off a real coup. With the American James Turrell, an internationally acclaimed artist could be won over to create a light installation specially designed for this location. Turrell, born in Los Angeles in 1948, has dedicated his artistic work to exploring the (im)materiality and perception of light for over five decades.

With reference to the Byzantine icon of the "Lukas Madonna", a highlight exhibit of the collection, an immersive, meditative light room was created, which the artist entitled "A CHAPEL FOR LUKE and his scribe Lucius Cyrene", illuminated in various shimmering hues. The title already suggests a spiritual-religious association on the sensory level. But the fact is that, regardless of whether you are a believer or not, you leave the light Installation strangely changed, even introspective and enriched by a haunting experience.

Upon entering the museum building and its imposing atrium, you get a first, still vague glimpse

of the light-intensive play of colors inside the chapel through a central arched opening above a staircase. And it immediately casts a spell over you. As you walk up the stairs, you are stopped halfway up on a landing to put on overshoes over your footwear, because just like entering a laser laboratory, you are about stepping into a clean room. And this is where the illusion begins. You instinctively want to lean on the staircase with its colorfully illuminated wall to keep your balance when putting on the plastic gaiters, before you suddenly realize that there is no wall reveal here at all. This is because the area is concave and so cleverly lit from the inside that an actual wall surface is only suggested by the uniform glow of the light and our sensory perception is deceived. As you continue upwards, you first have to cross a raised threshold, which symbolically makes it clear that you are now entering a different area, separated from all usual surroundings.

And then you are immersed in an all-pervading sea of color, whose intense spherical light mists change very gradually, almost imperceptibly, until a different hue dominates the room. As the room is uniformly rounded at the top and bottom of the field of vision and has no distinctive corner points that would suggest a boundary you lose your orientation in this all-encompassing flood of color, due to a loss of depth perception. You move slowly, carefully feeling your way

with your feet to a small bench, in front of which you can see a circular recess in the rounded front wall, illuminated from behind in a different color. Viewed from the front, it looks like a disk, which is perceived purely associatively as a kind of sun symbol, but can also be understood as a three dimensional tunnel segment connecting two areas when moving through the space. Due to the elimination of orientation points, it feels like standing in a homogeneous "Ganzfeld of pure light which gives the impression of losing the sense of space and time. If you are lucky enough to have the room to yourself for a few moments, you can concentrate fully on your own awareness within this diffuse, iridescent cocoon of light. And on what this perception does to you. Because this completely unfamiliar situation with its flickering atmosphere of light, which transports you to the bottom of a shimmering ocean, may take you back to the sensations of your earliest childhood. To a time in our lives when we simply perceived phenomena and things with all our senses as given and did not evaluate, judge, categorize, question and thus "disenchant" them, until we finally became more and more dulled in our perception by the reflexive classification of our detached minds.

Turrell's light installation is a stimulation of the senses, perhaps also a sensory overload. But it allows us to feel and perceive ourselves anew and touches our emotions in a variety of ways by reminding us of all that is fundamental and bringing it to our attention, in the same way as plants instinctively search for the light to live. But even if you share the spatial experience with other visitors, it remains a fascinating moment, precisely because you can see from the others and their astonished and relaxed joyful facial expressions how you are probably doing. And often the eyes of the people in the room meet, indeed seek each other out for an unspoken exchange and reassurance that this is a shared and special moment before everyone goes their separate ways again.

Turrell once compared the feeling one can have in his chapel flooded with light to a snowstorm. When you get into it, he explains, there is no horizon and therefore no orientation. At some point, you would lose your sense of above and below and, in the end, perhaps even your sense of yourself. In research, he goes on to explain, this is referred to as a "whiteout".

Unlike most artists, Turell works entirely with the use and effect of light as a means of artistic expression, pursuing an approach that has become his credo. He describes his artistic strategy as follows:

"First of all, I don't deal with objects. I am only concerned with perception. Secondly, I don't have an image because I want to avoid associative, symbolic thoughts. Thirdly, I don't set a focus or a specific point to which attention should be directed. But what do you look at without an object, without an image and without a focus? You look at yourself as you look. This happens in response to our seeing and the self-recognizing process of looking at oneself while seeing. Through seeing, you can increase feeling to touching."

And he adds that for him, light is not just an artistic medium for the purpose, but the actual purpose itself: **"Light is not so much something that reveals, as it is itself the revelation."**

For further information, please use the QR code below:

contact:

Diözesanmuseum Freising
Domberg 21
85354 Freising
Phone: +49.89.213774240

www.dimu-freising.de/museum/james-turrell

PhotonLab

Since 2011, the PhotonLab at the Max Planck-Institute of Quantum Optics has been a focal point for physics classes and students, who want to experiment with light individually. The facility was built by the institutions and excellence clusters MPQ, LMU, MCQST, MCQ and FOR 2783 and is visited by about 2000 interested students per year.

climate change in a suitcase

january 4, 2024 // Henry Hill & Sofie Silbermann

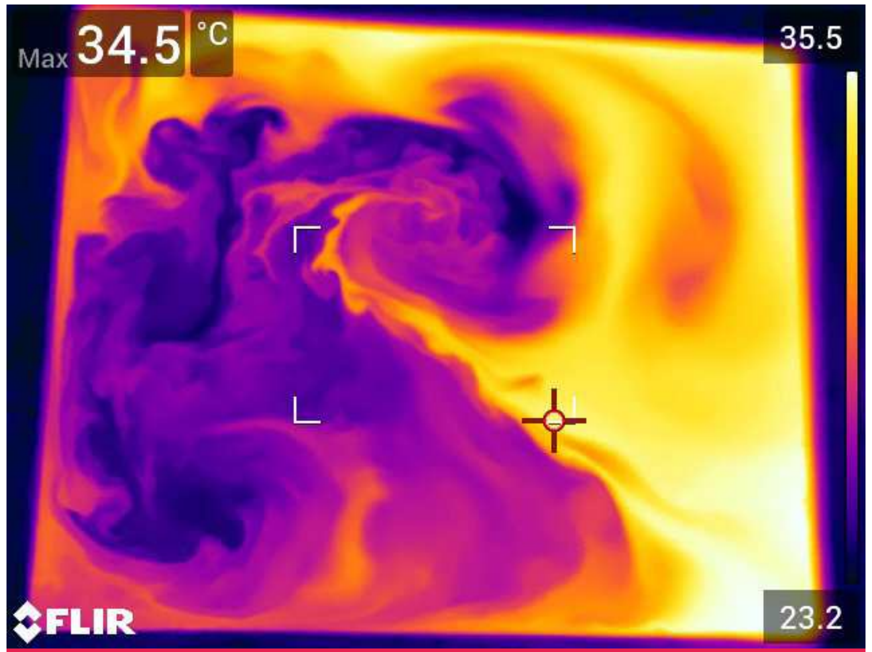
In our student laboratory PhotonLab at the MPQ, we not only deal with light and its (quantum mechanical) properties, but also shed light on the biggest problem of our time in the truest sense of the word: man-made climate change. Our latest experiment is based on the LMU's climate suitcase, which we use to explain the main cause of the rise in the average temperature of the Earth's surface due to anthropogenic fossil emissions in an age-appropriate way. To do this, we need to understand how invisible infrared light from the sun interacts with our atmosphere. Henry Hill supported Sofie Silbermann in setting up the experiment and the instructions at the PhotonLab. Here he presents the experiment.

Although infrared light is not visible, it can be perceived as heat. It is hard to imagine everyday life without infrared light: thermal imaging cameras, for example, help the fire brigade to illuminate opaque rooms and remote controls are also based on infrared light. In our experiment at the PhotonLab, we want to make students understand the significance of this electromagnetic radiation for humans and the environment, in addition to its scientific implementation.

We have prepared a new experiment in which students learn how carbon dioxide affects the Earth's radiation budget and thus its temperature and ultimately the climate change. In this experiment, we provide a hands-on experience with infrared light so that they can experience climate change with their own eyes. However, such an experiment cannot accurately depict the Earth, because our climate is very complex and a tiny change is barely perceptible on a small scale. But in the laboratory, it is sufficient to simulate the Earth as a small box ("infrared chamber"), because the effect is based on the same considerations: We want to show that the temperature in the atmosphere increases as a function of the added CO_2 content when infrared light shines in. This is because greenhouse gases absorb infrared light.

Filling the "infrared chamber" with CO_2 while watching this with the infrared camera. Photo: PhotonLab / Henry Hill

To begin with, it is important to understand that infrared light has different effects than visible light. To achieve this, we have an infrared thermal imaging camera in the laboratory. At the beginning, the students have to solve a few small tasks with this camera. For example, they use the thermal imaging camera to look at their handprint on a wall. Then, they realize that they can see through a balloon with the thermal imaging camera – as if by magic! They then observe the mixing of cold and warm water using the thermal imaging camera. Finally, they discover that normal window glass is impermeable to infrared light. The aim here is to find out that greenhouse gases have the following properties: They absorb infrared radiation and allow visible light to pass through – just like cling film and glass.



Mixing of hot and cold water. Photo: PhotonLab / Henry Hill

This is not only fun, but also teaches the students about the behaviour of infrared light. They learn about the radiation of black bodies, the transmission, emission and reflection of light. At the same time, they get some interesting pictures to look at. The pupils also learn about the famous diagram from the IPCC (Intergovernmental Panel on Climate Change), which shows the atmospheric CO_2 concentration in ppm against time, and they deduce for themselves that the CO_2 concentration has risen sharply compared to the pre-industrial age due to anthropogenic fossil emissions.

At the beginning of the actual advanced experiment, the students first measure the temperature in a small transparent infrared chamber, our model for the Earth. This is heated by an infrared heating element as a model for the sun. Then we let the students produce their own CO_2 using citric acid and baking soda and pour it into the chamber. To see the results, they now wait 3–4 minutes while they measure and record the continuously rising temperature.

The Students make their own CO2 with citric acid and baking soda before pouring the chamber.
Photo: PhotonLab / Henry Hill

Now the students can clearly see the results of adding a greenhouse gas to a sealed system both on the thermal imaging camera screen and on the thermometer. The temperature increases significantly by up to 7° C – and all in under five minutes!
An experiment like this clearly illustrates the relationship between CO2 levels and the temperature of our atmosphere. Of course, this experiment is only a small step towards understanding the physical processes on Earth. But raising awareness of this phenomenon is one way to help sensitise the next generation to global warming.

Here at PhotonLab, we look forward to inspiring the next generation of researchers and raising awareness of the consequences of climate change.

More information: ***www.photonworld.de/photonlab***

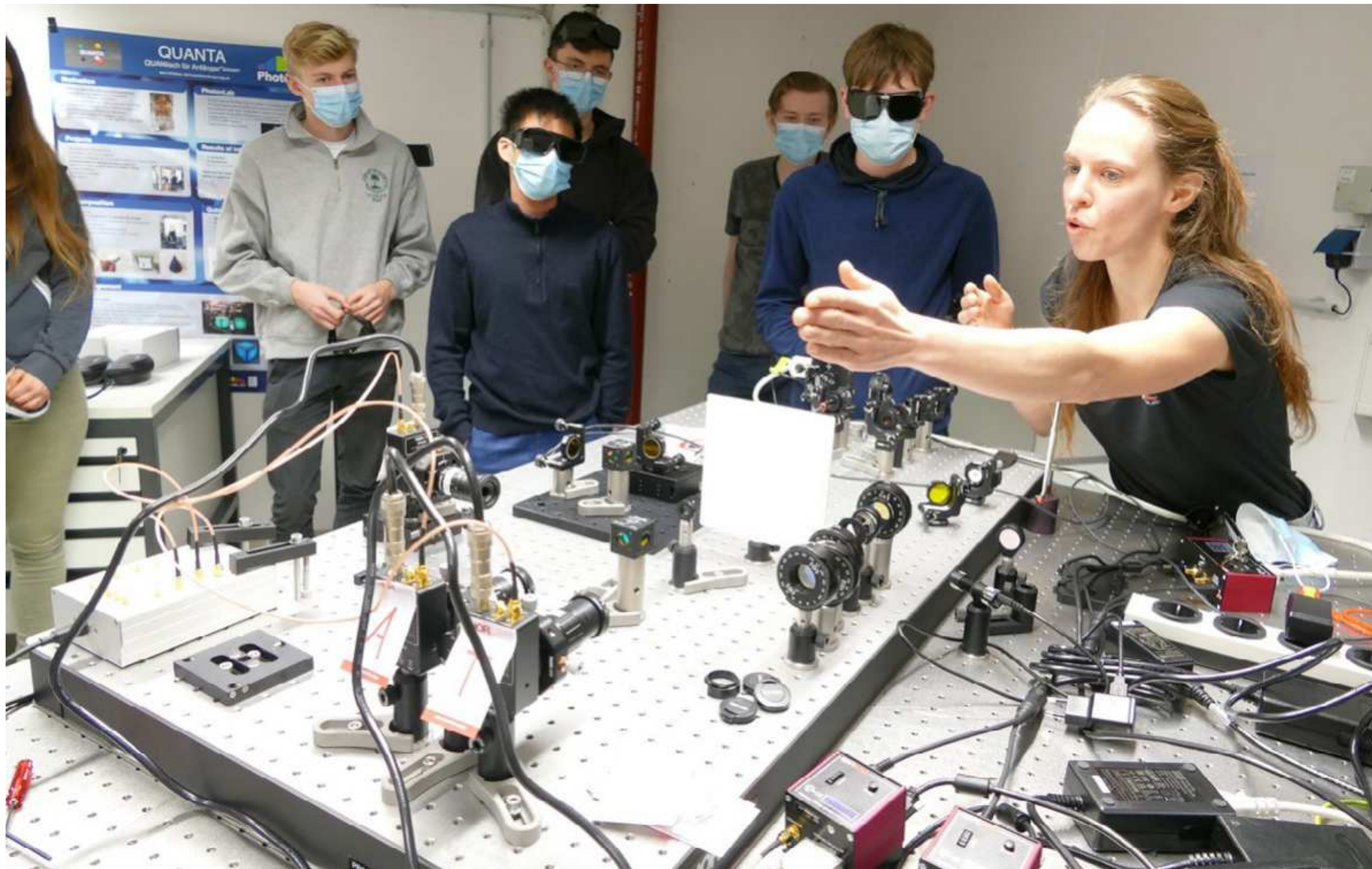
PhotonLab

my dream job has come true

january 4, 2024 // Soňa Ertlová

Some of you might know Soňa Ertlova from the corridors of the MPQ. You can recognize her by her T-shirt with the PhotonLab and Alice in Quantumland logo, or by accompanying a school group. Here she explains how she ended up in the PhotonLab student laboratory at MPQ.

I grew up in Bratislava and as a child I was fascinated by phenomena like rainbow, red or blue sky and stars. I started learning German when I was 17 and for some strange reason I really liked it. At the same age, I took a language course in Munich during the school holidays and fell in love with the city. My dream was to study physics at the LMU, but the combination of unaffordable housing and a challenging subject in a foreign language at such a prestigious university made it unrealistic. So I decided to study Film, Theatre and Media Studies at the University of Vienna instead.



Soňa Ertlová explains the single photon experiment of MQV to school students. Photo: PhotonLab

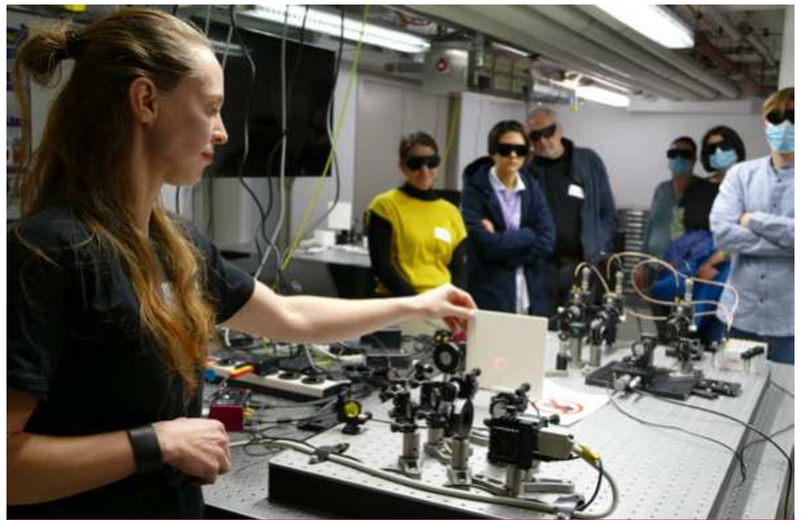
PhotonLab

Every school class starts with the Maiman-Laser at the entrance hall. Photo: PhotonLab

After quickly realizing that this wasn't the right choice for me, I worked as an au pair near Munich and then enrolled in a bachelor's program in physics at the LMU. For the practical course, I chose to do the experiment on laser spectroscopy. It was supervised by Mathias Mader, who was a PhD student in Prof. Theodor Hänsch's group at the time. Later on, during my Master's degree, he also supervised the course on "How to give a scientific talk".

After doing my bachelor's thesis on simulations of planet formation, I wanted my master's thesis to be much more practical, experimental physics, playing with Lego, light and lasers. So I asked Matthias about a possible master's thesis. He welcomed me very warmly and with him as my supervisor, we started shooting holes in the air with lasers together (literally, since we were doing photothermal spectroscopy of atmospheric gases using a fibre cavity as a microsensor). I learnt a lot from him, as he is a great person and an experimental physicist. I also learnt a lot about photonics from the lectures of Prof. Ioachim Pupeza, whom I also greatly admire.

After my Master's thesis, I did not know what to do next. I wanted to talk about and explain the physical phenomena that had fascinated me since childhood and to spread this fascination. Then I saw the job advert for the student lab – PhotonLab – online, looking for someone with a Master's degree in physics (laser physics, optics). I was happy to join the PhotonLab team in April 2022. I can now talk to students about physics without having to assess them or teach at school. The PhotonLab is directly linked to the research through its location at the MPQ in the division of Prof. Ferenc Krausz and its collaboration with MCQST and MQV. My position is also partly funded by MQV. I set up the MQV-financed single-photon experiment in January 2023 (with a lot of voluntary help from Matthias, who was looking for a new job at the time), and since then Silke Stähler-Schöpf, Linda Querimi and I have developed a special course for groups interested in quantum mechanics. We can show them the interference of single photons using a Barium borate -generated photon pair source and a Michelson interferometer. Otherwise, the program for the school classes is often similar, but each group is different. We start with showing the world's first laser and then take a look at the inside of a science laboratory. Here we briefly explain the principle of attosecond physics and the current research of the ATTOWORLD-group. Students can then choose from 25 experiments in the PhotonLab. Sometimes we even experiment with liquid nitrogen, for example to demonstrate superconductivity. I'm very grateful that with such great and enthusiastic director as Silke, our working students and all the people from the research community who support us, my dream job has come true.



Teachers training at the single photon experiment with Soňa.
Photo: PhotonLab

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www.photonworld.de/photonlab

Light is the engine of life. It is a volatile medium. However, mankind understands better and better how to make use of the radiation. If you would like to inform yourself about current topics related to light, the photonworld.de homepage is the right place for you. Here, the ATTOWORLD-team reports in a generally understandable way about exciting findings and discoveries in physics, biology, chemistry or astronomy. The authors explain how to use light in technology and what visions are coming through the minds of researchers and engineers to make light the tool of the 21st century. On the following pages we publish some samples.

Emmy meets Albert

january 2, 2024 // Thorsten Naeser

Emmy Noether was honoured by none other than Albert Einstein. In his obituary in 1935, he wrote about the mathematician: "She was the most important creative mathematical genius since the introduction of higher education for women." Gesine Born has a similar opinion. The Berlin-based science communicator has now also honoured Emmy Noether once again – through her images, generated by artificial intelligence.

Emmy Noether is talking to Albert Einstein, street photography, Leica style, 1920
Illustration: Gesine Born with "Midjourney"

Unfortunately, there are no pictures of Albert Einstein and Emmy Noether together. But Gesine Born has considered what such a meeting might have looked like. Using the AI-based programme Midjourney, the Berlin-based science communicator has captured the two luminaries of the natural sciences in a picture. They appear to be having a lively discussion at eye level in a rather private moment. One wonders whether such a photo could have been taken on the fringes of one of the major scientific conferences of the time. But then you come to the conclusion that you have never seen it before.

What Albert Einstein and Emmy Noether are talking about in this virtually created situation is left to everyone's imagination. In any case, the picture takes the viewer back to the early 20th century, when so many discoveries were made that still characterise our view of the world today. This also applies to the work of Emmy Noether.

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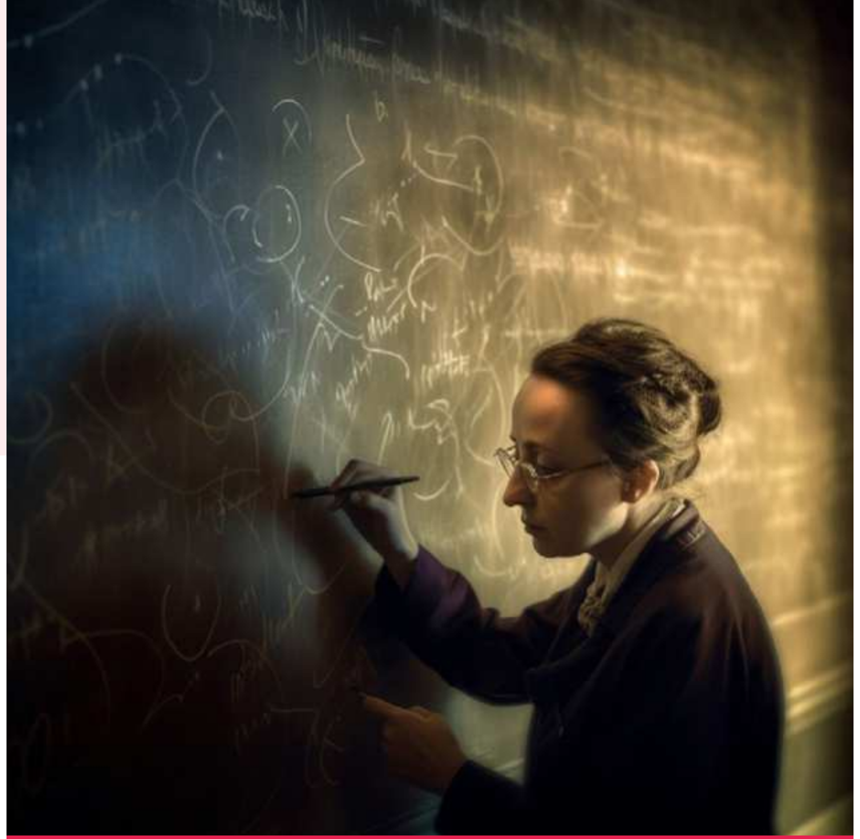

Emmy Noether writing on a wall an equation of the function with the letters e and i, in the style of light emotive energy, quantumpunk, erol otus, science-based.
Illustration: Gesine Born with "Midjourney"

Emmy Noether (1882–1935) was the first German woman to complete a doctorate at the University of Erlangen. She worked at the Erlangen Mathematical Institute for eight years without pay. Her publications made her so well known that the great mathematicians Felix Klein and David Hilbert invited her to Göttingen in 1915. It was not until 1922 that she became the first woman in Germany to habilitate and take up a professorship. Her pioneering work on modern algebra was written in the following years in Göttingen. Noether's normalisation law and Noether's rings are named after her. She was forced to leave Germany by the Nazis because of her Jewish ancestry.

Gesine Born now provides a somewhat subjective insight into Emmy Noether's scientific work with her AI-generated portraits of the legendary mathematician. "With my pictures, I want to give women in science more visibility," says Gesine Born. Especially in the era in which Emmy Noether lived, only a few women were able to demonstrate their skills in the natural sciences. "With my pictures, I primarily show their scientific achievements and put the spotlight on their findings," says the science communicator. It takes Gesine Born around a day to generate a handful of satisfactory images of a female researcher. She has also created such sets of images of physicist Lise Meitner and mathematician Katherine Johnson, among others.

The images can be admired on the website of the image institute founded by Gesine Born (www.bilderinstitut.de) or on her LinkedIn account (Gesine Born).

Emmy Noether, the brilliant woman in mathematics is forming a circle on a black background, in the style of Bertil Nilsson, Olympus AF-1 (aka Olympus infinity), Albert Goodwin, Cornelia Parker, 8k, trashcore, abrasive authenticity.
Illustration: Gesine Born with "Midjourney"

www.bilderinstitut.de

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how artificial intelligence can influence our lives?

december 5, 2023 // Vasileios Papalampropoulos

It is very well known that artificial intelligence (AI) is starting to become more relevant as time goes by, with its uses becoming more and more common in our everyday lives. The main question amongst the techno skeptics is if that technology can improve our lives or become a malicious tool used to suppress us. In this following article we are going to dive into the world of AI applications discussing some fears and hopes of the biggest minds in the field.

Illustration: Vasileios Papalampropoulos with "Bing Image Creator"

One good way to start the conversation is to explain what exactly Artificial intelligence is. Most people thoughts on the matter are mainly influenced by sci-fi movies with them often making the mistake to confuse **AI** with **Artificial general Intelligence (AGI)**. The key difference between the two is that AI exists today and has very limited specialized functions while AGI is still a theoretical pursuit in the field of artificial intelligence. Artificial General intelligence is a form of intelligence that reaches a human level of cognition and once this technology is created, we are going to reach the so called "technological singularity" a point where there is going to be an explosion in intelligence since AGI unlike humans can modify both it's hardware and software to become even "smarter". Humans took hundreds of thousands of years to evolve mainly because of how slow the evolution process is, on the other hand an artificial general intelligence can design itself improving exponentially in a very short amount of time[1]. Most specialist in the field estimate that a "technological singularity" can occur in 10–20 years from now with some estimating the end of the century (2100) with the most pessimistic thinking that a development of such technology is impossible to achieve. So, we can clearly see how this technology managed to create a plethora of different opinions about not only it's uses but also the time needed to develop that kind of technology.

Since artificial general intelligence may be far away from materializing, we will focus mainly on how humans can use the AI applications existing today and not how a sentient artificial general intelligence may act. AI today consists of very specialized tools used for very specific tasks. From the most common use that is face recognition used by both regular phones but also security agencies to the most complex forms used in scientific research, AI has completely automated tasks that previously had to be done by a human. Google maps has a built-in function that allows the user to know the fastest path using AI to calculate the traffic by collecting location data from its users. Each driver's phone sends its location using GPS coordinates with the app being able to identify higher congestion in particular parts of the city as well as the speed and direction of each driver resulting in a better driving experience. One other way AI might be useful is a proposal to develop a software that can detect skin cancer just by photographing a skin lesion with a regular phone. The user takes a photograph of the skin and the AI having been trained with thousands of photographs of skin cancers can detect with high accuracy if a lesion is malignant. With melanomas accounting for 75% of all skin cancer related deaths such a technology may help identify cancer on earlier stages[2].

AI has already shown us the ability to drive cars without the need of a driver with many experts estimating that self-driving cars will be the majority by 2035. When self-driving cars become safer than the

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average driver there is the possibility that car insurance companies will increase the fees to insure human driven cars or even denying insurance at all. This has caused some concern to car enthusiasts who will be forced to stop driving but generally that transition will reduce drastically the traffic-related accidents and fatalities. The transition will probably start happening as an organic process in the following decades.

One big concern can also be the AI generated art that can create a shift in the market effecting professions like graphic designers and artists[3]. Today's AI can create complex pieces of art in just few seconds with the user being able to just give a text description as the input while getting an image as the output. This may come as far as effecting even architects or social engineers as AI may be able to generate an architectural building using different models to check the design as

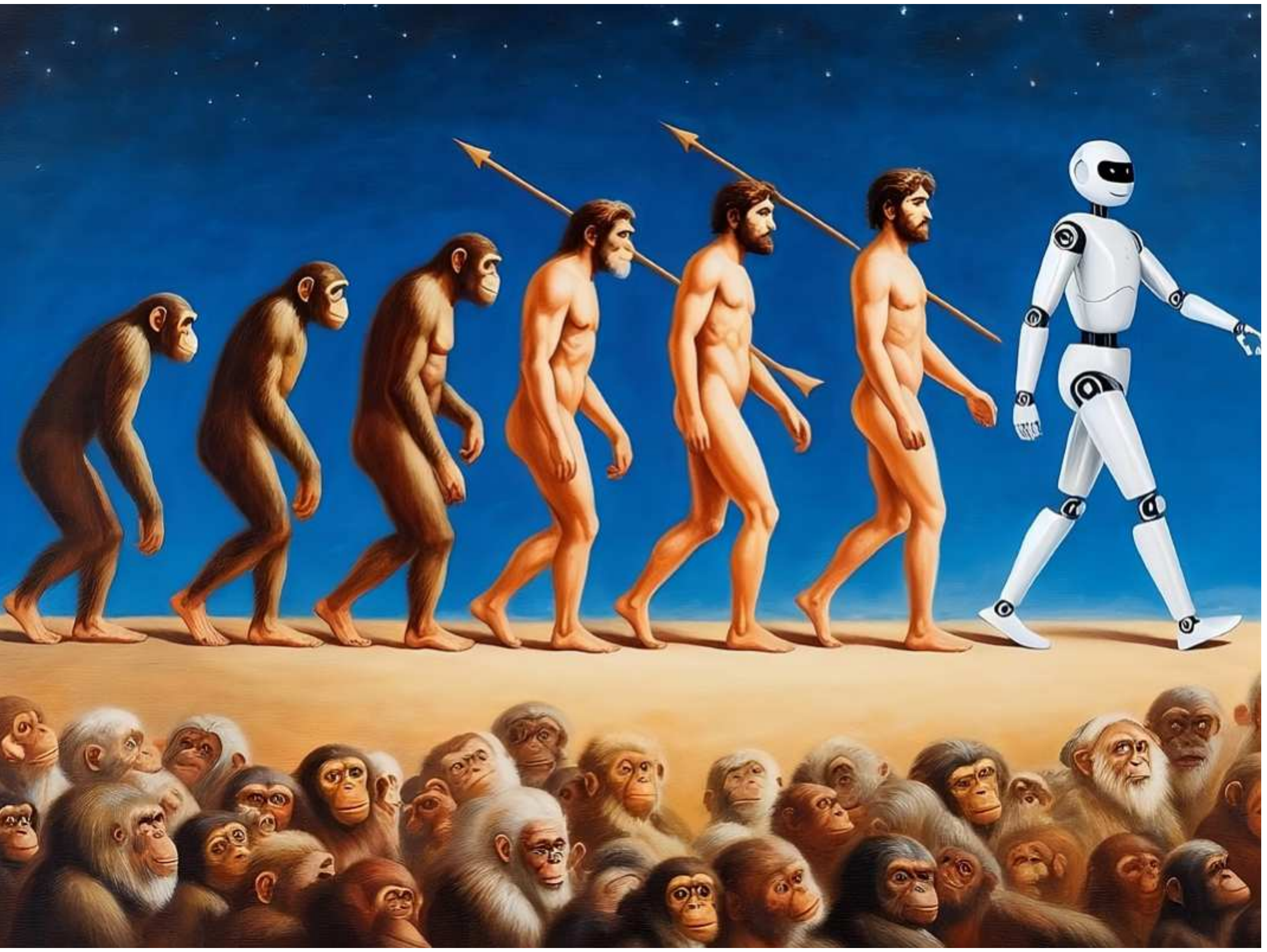


Illustration: Vasileios Papalampropoulos with "Bing Image Creator"

well as its structural integrity. The music production market can also become extremely saturated with AI creating new music easier than before. AI can automate many tasks making one person complete the tasks usually done by three or even more people reducing the human resources and thus causing unemployment in those fields with only the most prominent people being unaffected.

Skepticism has also appeared to the developing of more complex AI models that can generate photorealistic video and the implication this may cause in the judicial system. CCTV footage presented in court was always considered an undeniable piece of evidence that could completely affect the results of the jury. With AI being able to create lifelike video and audio using Deepfake, any digital evidence presented in court will be rendered useless in the near future. AI has also caused unrest in people minds because of its ability to create fake news with the use of video and audio generation. There are numerous videos online displaying the possibilities of this technology containing talks by government officials that are generated by AI to a very realistic extent. As many computer specialists have stated, the new way of propaganda is not trying to suppress the truth but to make it extremely difficult to find in a world of misinformation.

Finally, it's time to address some malicious uses for AI that may be used to turn our liberal societies into a totalitarian surveillance state. One good example is the possible use in the Social Credit System that is currently being tested in some provinces in China and has sparked criticism from many organizations for being authoritarian. This system scores each citizen with some credit points that indicate how "well-behaved" is that citizen for society. For each misdemeanor a citizen score will be reduced resulting in some penalties like not being able to get a loan or being subjected to travel bans. Until 2023 AI is not being used extensively with humans being the ones who are making the penalty decisions but that will certainly need to change if this system goes into full scale. In order to monitor hundreds of millions of people living in very densely populated areas you need to completely automate that process and that can only happen with the use of AI. There are many concerns about an AI that has a facial recognition system with the ability to recognize you from surveillance cameras using our biometric data and automatically charge you with a penalty without the need for a human operator. This can result in a surveillance state like the one depicted in Georges Orwell book 1984.

It is sure that AI is destined to change our lives. With the creation of general artificial intelligence being decades away we discussed the uses of AI operated by humans because it is extremely hard to predict what will happen when AI reaches human level intellect. The only thing that can be sure is that the world will never be the same after that.

[1] Life 3.0: Being Human in the Age of Artificial Intelligence

[2] **dermatologist-level classification of skin cancer with deep neural networks**
AUTHORS: A. Esteva, B. Kuprel, R. A. Novoa, J. Ko, S. M. Swetter, H. M. Blau & S. Thrun
JOURNAL: ***Nature* 542**, 115 (2017)

[3] Midjourney is a generative artificial intelligence program and service created and hosted by San Francisco-based independent research lab Midjourney, Inc. Midjourney generates images from natural language descriptions.

nasty fungis and sleeping dinosaurs

september 18, 2023 // Thorsten Naeser

A photo of a colorful fungus has earned biologist Cornelia Sattler from Australia's Macquarie University first place in the photo competition of the magazine "BMC Ecology and Evolution". Every year, the magazine calls on scientists around the world to submit their best pictures taken during their work.

An invasive orange pore fungus poses unknown ecological consequences for Australian ecosytems. Image: Cornelia Sattler

Cornelia Sattler's photo shows an orange fungi. Despite its innocent and beautiful appearance, the fungus is causing concern in Australia. This is because it is an invasive species. It displaces other fungis and is spreading in the Australian rainforest. The bright orange fruiting bodies grow on dead wood and spread by spores.

Victor Huertas from the Hoey Reef Ecology Lab at James Cook University in Australia took the winning photo in the "Research in Action" category. The photo captures the moment when the team deployed a remote-controlled underwater vehicle on Diamond Reef in the Coral Sea Marine Park. The team used the diving robot to discover new species in the reef. The jury commented: "The photo captures the essence of ecological studies. It shows us how humans operate at the interface between the atmosphere and the hydrosphere."

Exploring the deep. Researchers from the Hoey Reef Ecology Lab deploy an underwater ROV at Diamond Reef within the Coral Sea Marine Park.
Photo: Victor Huertas

Victor Huertas also took the picture of biologist Jodie Rummer. In Mo'orea, French Polynesia, the professor from James Cook University in Australia releases a newborn blacktip reef shark into the wild. She had previously tagged it and recorded its biometric data.

The winning image in the "Paleoecology" category was submitted by Jordan Mallon from the Canadian Museum of Nature. Jordan's entry shows the AI visualization of the inside of a hadrosaur's egg. The original was found in the red layers of the Upper Cretaceous period (72 to 66 million years ago) in China. The size of the eggs and the unspecialized nature of the embryos inside indicate that the earliest hadrosaurs laid small eggs and hatched the young. Later hadrosaurs laid eggs that were almost four times larger and hatched larger young. The paleontologists took all the information that went into the digital image from the original fossil record. The AI illustration thus shows us the astonishing wealth of information contained in fossils, according to the jury.

Protecting future generations of reef sharks. A researcher releases a new-born blacktip reef shark in Mo'orea, French Polynesia.
Photo: Victor Huertas

A peek inside a hadrosaur egg.
Image: Jordan Mallon & Wenyu Ren

original publication:

2023 BMC Ecology and Evolution image competition: the winning images
AUTHORS: J. Harmani, C. A. Hipsley, L.M. Jacobus, David A. Liberles, J. Settele & A. Traulsen
JOURNAL: ***BMC Ecology and Evolution* 23**, 32 (2023)

the marvellous journey of life

january 4, 2024 // Thorsten Naeser

It is a flourishing world travelling through the inhospitable universe. The lush green life unfolds under huge glass domes that fly through the dark expanses of space. The futuristic scenario was created by Andre Kara with the help of the artificial intelligence of Dall-E and Krea. "The image has a special meaning for me as it was inspired by the iconic sci-fi film 'Silent Running'. The film is timeless and inspiring," says Kara.

"From my earliest memories, I have been passionate about emerging technologies and software innovations," he contnues. "My fascination with science fiction was also sparked back then." The imaginative cover art of classic science fiction literature and series such as Perry Rhodan, as well as the works of H.G. Wells, Arthur C. Clarke and Isaac Asimov, played a large part in this. "These influences have driven me to explore the latest AI tools. They allow me to create images I've always wanted to see myself."

To share his ideas, Kara has set up the Instagram account: _spaceage42. "For me, it's a way to deal with the frustration of the gap between the limitless potential of technological advances, the infinite possibilities of space and the frustrating reality of our current slow progress."

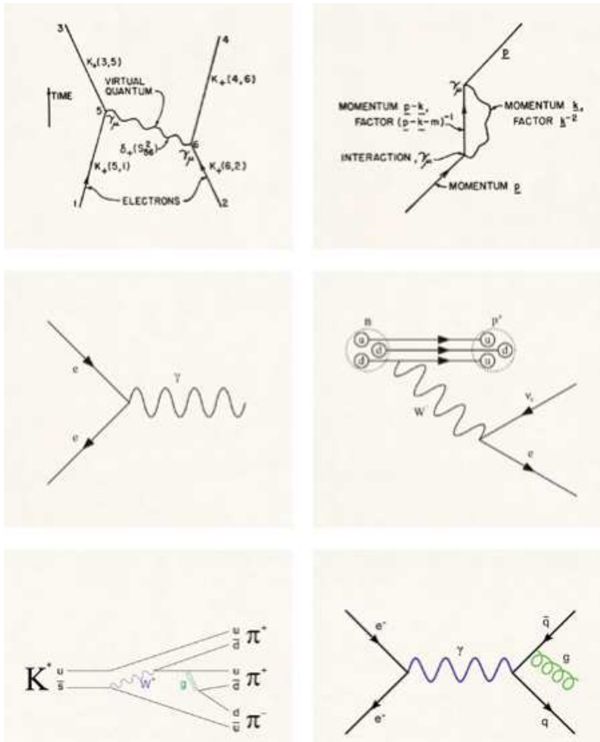
Illustration: Andre Kara

www.instagram.com/_spaceage42

visualisation makes science sexy

january 2, 2024 // Thorsten Naeser

Nothing makes science more attractive than good visualisation. It is the visualisation that gives research its sex appeal. Be it a photo, a clear sketch or a convincing graphic. It is a great art to give scientific findings a face and communicate them visually in such a way that everyone understands them. What is now professionally realised by graphics experts in press offices or advertising agencies was done by natural scientists themselves in the early days of scientific communication.



Feynman diagrams are abstract but precise pictorial representations showing the movements of elementary particles interacting in a given model. They were invented by the theoretical physicist Richard Feynman, who first presented them in 1949. Each straight line represents a particle and each vertex shows its interactions. Feynman diagrams are also used in statistical mechanics and in the manybody problem, where they offer a simpler, more visual way of working than using direct mathematical expressions. Image: TASCHEN Verlag

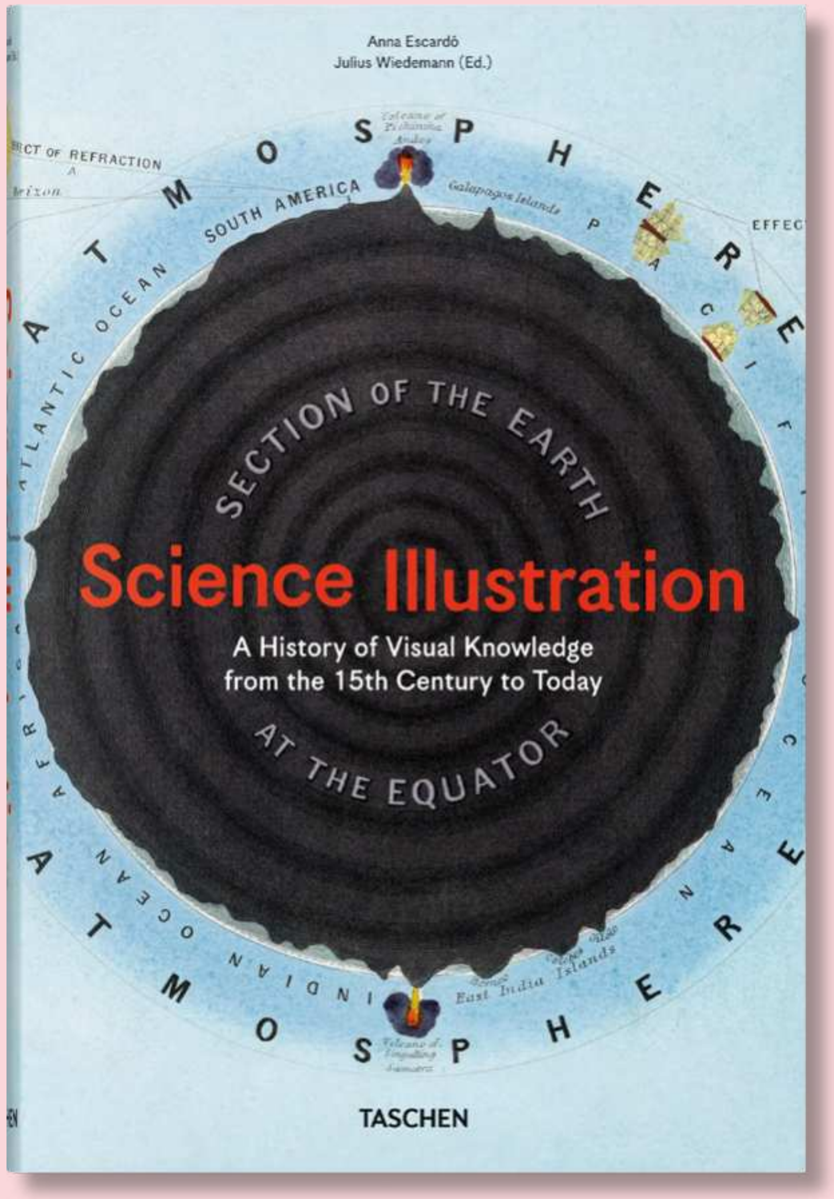
The beginnings of scientific drawings lies in the dark. Even before the 15th century, there were bestiaries and herbaria with illustrations that were descriptive and functional. However, if we assume that modern science began with the scientific revolution, then we quickly come across Albrecht Dürer as the forefather of scientific illustration. In 1502, he painted a rabbit. He focussed on the physiology of the animal without allowing himself to be distracted by aesthetic considerations. Dürer thus strove for a faithful reproduction of his research object. Another great pioneer of scientific drawing was Leonardo da Vinci, who produced a vast number of depictions of machines and natural objects, especially anatomy.

Author Anna Escardó and editor Julius Wiedemann have compiled pioneering, artistic and sometimes bizarre illustrations from the history of scientific illustrations in the book "Science illustrations". The opulent volume features works by more than 700 scientists, including anatomists, physicists, chemists and astronomers.

With detailed articles (in English, German and French) about their scientific significance, the illustrations in this book present the work of pioneering researchers such as Andreas Vesalius, Isaac Newton, Marie Curie and Rosalind Franklin. The illustrations themselves show groundbreaking ideas and discoveries from the 15th century to the present day, including Galileo's watercolours of the moon, Bourgery's incomparable atlas of human anatomy and surgery, Florence Nightingale's statistical diagrams of causes of death in war, and Einstein's quickly sketched ideas for his general theory of relativity.

Most of the illustrations are visually appealing. However, the depiction of mathematical and physical ideas in particular often proves to be difficult, while some revolutionary ideas were illustrated in an astonishingly simple way. For example, French scientist Charles François de Cisternay du Fay's 1733 description of the different types of electric charge and the laws governing their behaviour, distinguishing between glass and resin charge (now positive and negative charge). His drawings illustrated these ground-breaking findings in the simplest possible way. The same applies to the diagrams of the English meteorologist George Hadley, which he used in 1735 to describe the movement of the trade winds, i.e. the regular circulation of air between the equator and 30° north or south latitude.

"Science illustrations" is a book for art lovers, fans of the history of science, but also for researchers. As a scientist, you can get a lot of inspiration here on how to visualise your own findings and communicate them to the public in an exciting way.



Science Illustration
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ATTOWORLD is a home for synergies across institutions and borders. By uniting the teams of the MPQ Laboratory for Attosecond Physics, the LMU Chair of Experimental Physics – Laser Physics, and of the Centre for Advanced Laser Applications (CALA) and closely collaborating with researchers from the LMU Center for Molecular Fingerprinting (CMF), clinics of the LMU and the Helmholtz Zentrum München in the Lasers4Life (L4L) Collaboration.

We pursue – supported by UltraFast Innovations (UFI) – transfer of our technological developments to interested research groups all over the world, exemplified by the creation of the Attosecond Science Laboratory at King Saud University, the first of its kind in the Arabic World. We feel obliged to disseminate the knowledge we acquire and are glad to share our findings, provide advice and technical assistance to researchers of any public institution of the world committed to advancing science, technology or medicine. Do get in touch if you are interested!

Our Logo displays the first light wave ever captured, in this case a few-cycle wave of red laser light. It was recorded with attosecond flashes of light, establishing attosecond metrology, the fastest metrology on Earth.

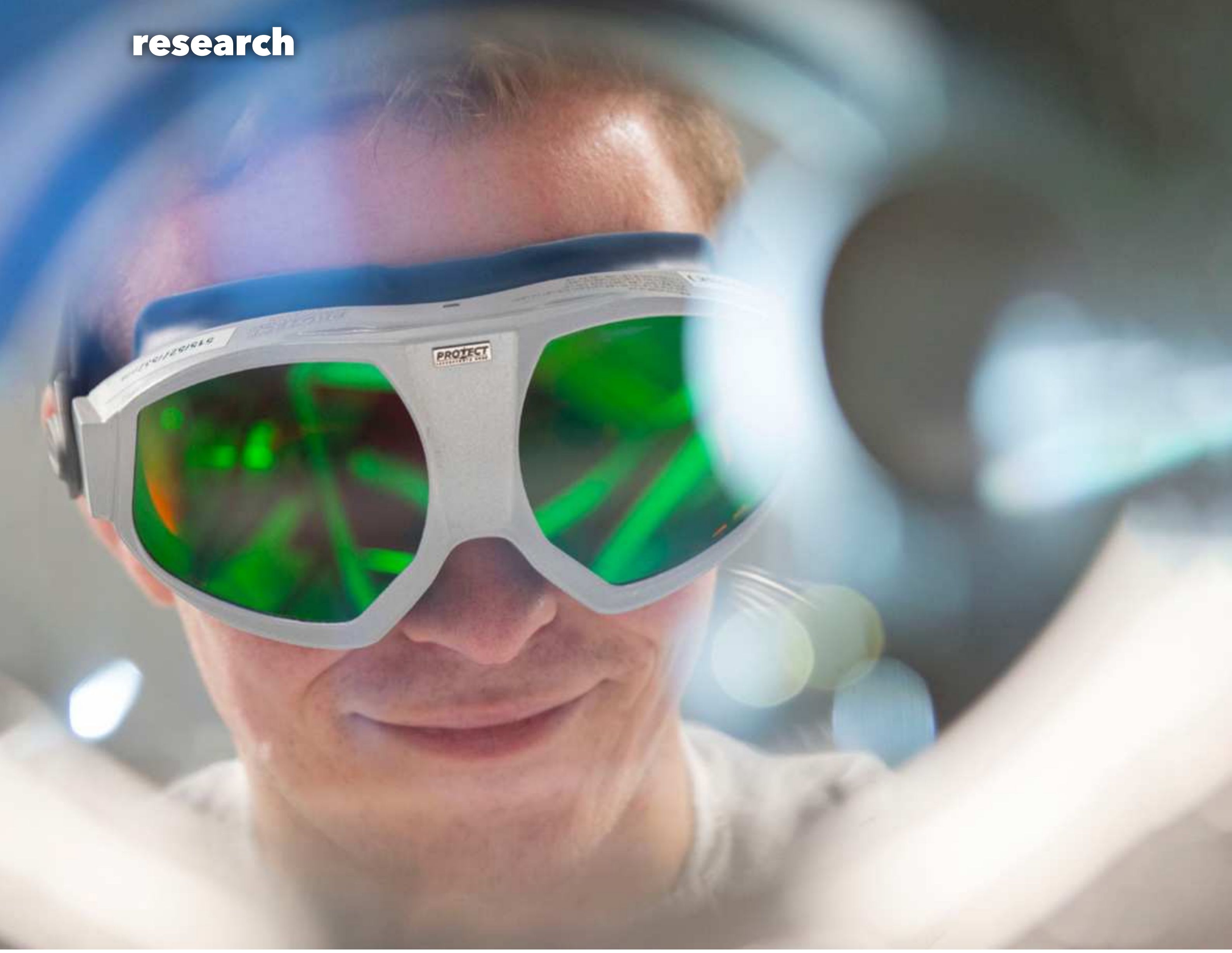

Photo: Thorsten Naeser

a clear view at the HORUS beamline

february 1, 2024 // Dr. Thomas Nubbemeyer

During the last two years our attosecond beamline infrastructure has been extended by the new HORUS SXR beamline system for generation of XUV and soft-X-ray pulses in the water window. It is driven by our state-of-the-art 2µm SWIR source HORUS (High-power OPCPA system for high Repetition rate Ultrafast Spectroscopy) which provides ultra-short 20 fs laser pulses at 10 kHz repetition rate and with up to 5 mJ of pulse energy.

The HORUS SXR beamline consists of an interferometric setup using HHG in an argon gas target and an IR bypass arm including a delay stage for pump-probe type experiments. Re-focussing into the experimental chamber is achieved with a toroidal mirror, a camera-based SXR spectrometer is available for diagnostics. XUV photon energies of up to 220 eV have been generated successfully with the current setup.

The apparatus promises versatile experiments reaching from transient-reflection studies, core level spectroscopy of atoms and molecules or X-ray driven current generation to field-sampling and nanoplasmonics.

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