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Light, which we perceive as a continuous stream of brightness, actually consists of rapidly oscillating electromagnetic waves. In the ATTOWORLD*-team Kafai Mak and his team are exploring a fascinating new way to gain even more control over lightwaves. See our feature article on page 8.* Photo: Thorsten Naeser



dear reader!

What do you think? Is this text my own work or was artificial intelligence used? It's hard to say. I have asked myself this question in many of the articles I have read recently. But rarely have I found a clear answer.

The fact is that the advance of artificial intelligence in every area of our lives is unstoppable. Be it in journalism, art, or science. Teachers, educators, and university lecturers are faced with the dilemma of recognizing AI in examinations and submitted work and evaluating it accordingly. Especially in work that claims to have generated new knowledge, this can be a challenging search for clues.

AI has become part of the ATTOWORLD-team's toolkit as well. For Kosmas Kepesidis and his data science team, AI is a daily essential, and it has also proven useful for the team led by Andreas Döpp at CALA. In the years to come, AI will certainly transform our world, and only time will reveal the extent to which it enriches our lives.

But what AI can't do — at least at the moment — is stand in the lab, experiment, try things out, and get creative. It's not just the researchers in the ATTOWORLD-team who are way ahead of artificial intelligence. And that's a good thing! Because this is the only way to generate new knowledge about the nature of things. Through people who are passionate about discovery and for whom science is an adventure. No AI in the world can conjure new scientific findings out of a hat. It can only help to structure and categorize them.

And so the public outreach team at ATTOWORLD is delighted to present you, dear colleagues, and hopefully many other people interested in laser physics, the new issue of our pulse magazine. AI has also found its way into this issue in many ways. However, the focus is on the meticulous research work carried out by the ATTOWORLD-team over the past year and the exciting findings that have been gathered in the process — with and without AI.



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Head of Public Relations

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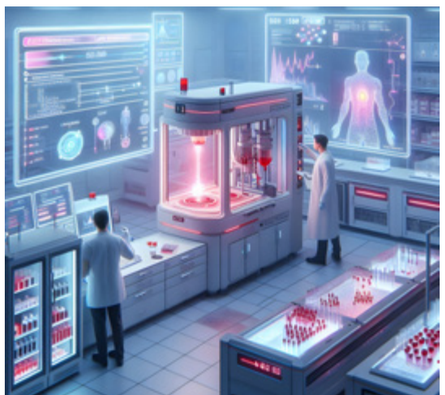
In a festive ceremony in October 2024, Ferenc Krausz and Anne L' Huillier were appointed honorary doctors at the Faculty of Science and Technology, at Umeå University in the middle of Sweden.



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a drop of blood, many diagnoses: infrared spectroscopy for rapid health screening

Using infrared light and machine learning, researchers have developed a method to effectively screen human health and its deviations at a population level.



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AI amidst technological revolution

It is very hard to pinpoint exactly the time AI swerved into our lives completely changing the possibilities available by the existing technology.

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.

one week without bombs

october 24, 2024 // Tanya Bergues

In the latest issue of our magazine 'pulse', we reported on our organization, Science4People e.V., which was founded after Russia's invasion of Ukraine. Our goal is to promote education and development opportunities for children and young people in war and crisis regions. This time our project coordinator Tanya Bergues likes to introduce a smaller project that was implemented with the help of our partner, Tabula Rasa for the future generation, in August 2024. Here's the story of the project "One Week Without Bombs".

As part of SKOLA+/SPORT+, we welcomed a group of students supported by a highly motivated teacher to our projects. These children from Marhanez, a town near the front lines, face a much more difficult daily life compared to students further inside the country. The proximity to the front line means they are in a constant state of stress, as they cannot have a 'normal' life: no free play outside, no regular in-person classes at school, no sports, and no larger groups outdoors. Daily shelling makes these normal activities too dangerous and nearly impossible.



Water fun at the aquapark. Photos: Tabula Rasa for the Future Generation

The idea of the project was to provide these children with a break, allowing them to spend a week in the comparably peaceful environmentin of the Transcarpathian region in the far west of Ukraine. The program was developed, tickets were booked, and after a 2000 km journey, the group of nine children, accompanied by a teacher, arrived in Batjovo, Transcarpathia. Together with the local schoolchildren, they experienced an eventful week. There was a visit to an old castle in Uzhhorod, a trip to a water park, a volleyball training session, an art class at the youth center Zdybanka, and much more. Above all, it was a beautiful time spent with newfound friends in nature. The guests from southern Ukraine had the chance to learn about and experience the history and traditions of a different region up close.



A day out in nature with friends.

For the local organizers and for us from afar, this visit was a wonderful experience. We could see how, with our help, an island of calm and relative peace had been created.

To enable more actions like this, please help us and support us as you can! Below you will find a QR code for more information and how you can help.





A sunny day by the lake.

A carefree excursion into the countryside.

general questions and donations:

Tanya Bergues
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science4people.org

seeing the light: the promise of electric-field-resolved detection

december 3, 2024 // field-resolved infrared spectroscopy

One promising technique for seeing the oscillating electro-magnetic field of light is via electro-optic sampling (EOS). But the technique can still be improved. In the ATTOWORLD-team Kafai Mak and his team are pioneering a novel approach aimed at circumventing the trade-off between detection bandwidth and efficiency. The team is exploring the use of an optical parametric amplification stage to amplify the signal before it reaches the EOS detection stage. By harnessing the power of direct electric-field measurements using EOS, electric-field-resolved molecular fingerprinting (EMF) could revolutionize how we detect illnesses before they manifest, potentially saving countless lives. Here Kafai Mak reports about the plans.

Light is an intriguing phenomenon. While we often perceive light as a continuous stream of brightness, fundamentally, it is an oscillating electromagnetic wave that darts through space at incredible speed. The peaks and troughs of these waves wiggle so rapidly that our eyes, and even most scientific instruments, only capture the overall strength of light rather than the underlying oscillations. Occasionally, we can glimpse the intrinsic wave effects through optical interferences (such as the colourful reflection seen on a thin film of oil on water). But for the most part, the waves are hidden beneath the surface.



Light, which we perceive as a continuous stream of brightness, actually consists of rapidly oscillating electromagnetic waves. Photos: Thorsten Naeser



Electro-optic sampling is able to measure the oscillating electric field of light via the Pockels effect.

One cannot overstate the potential of unlocking this hidden dimension. By carefully measuring the underlying waveform, a world of new opportunities is opened up: from studying the properties of semiconductors and thereby laying the foundation for next-generation electronics, to understanding fundamental physical phenomena such as the random fluctuations of electric fields in a vacuum.

One promising technique for seeing the wave is via electro-optic sampling (EOS). At the heart of EOS is the Pockels effect, a fascinating effect where the application of an electric field to a suitable nonlinear crystal alters its birefringence — the way it refracts light. By measuring the changes in birefringence as the raising and fading of the electric field passes through the crystal, scientists can trace out the electric waveform, revealing the subtle but crucial phase information (the relative timing of individual frequencies).



Kafai Mak (left) and Gerard Faustino (right) aligning the Cr:ZnS amplifier.

The history of EOS is rich and varied. It was first employed to investigate fast field transients in Pockel cells. Over time, the technique matured and is used for characterizing terahertz (THz) wavelengths, and later, researchers pushed the boundaries of measurable light into the mid-infrared (mid-IR) spectrum. The mid-IR region is of particular interest for bio-medical research since most biologically relevant molecules possess telltale absorption lines that can be detected using mid-IR light. This has already led to novel applications such as electric-field-resolved molecular fingerprinting (EMF).

The improved detection sensitivity and additional phase information offered by EMF holds immense potential for detecting the earliest hint of illness development. As the success rate of treating cancer and many other diseases is tremendously higher at an early stage, the importance of early detection and intervention is obvious. By harnessing the power of direct electric-field measurements using EOS, EMF could revolutionize how we detect illnesses before they manifest, potentially saving countless lives.

However, the development of EOS has not been without challenges. A notable trade-off exists between the detection bandwidth and efficiency. In other words, the more wavelengths one attempts to detect simultaneously in a single measurement, the less efficient and thereby less sensitive the overall measurement is. A broader bandwidth is advantageous as it allows for the concurrent detection of more mole-

cules, enhancing the technique's diagnostic capabilities. But a high sensitivity is also paramount for detecting the weakest changes in a sample's composition. The dilemma originates from the nonlinear crystals used in EOS detection: thinner crystals offer broader band detection, while thicker crystals enhance efficiency at the expense of bandwidth.



Sergio Revuelta inspecting the electro-optic sampler.

To address these challenges, our research team is pioneering a novel approach aimed at circumventing the trade-off between detection bandwidth and efficiency. We are exploring the use of an optical parametric amplification stage to amplify the signal before it reaches the EOS detection stage.

It uses an additional, complementary nonlinear crystal to divide up the tasks. Rather than changing its birefringence, the crystal can generate new wavelengths. By sending an additional powerful beam of light to coincide with an already propagating beam, energy can be transferred from one wavelength to another, raising the power of the original beam.

This amplification could boost the mid-IR signal by over 100 times its original strength and doing so over a broad bandwidth. It will allow us to maintain the high detection sensitivity that EOS is known for over a much wider spectral bandwidth. The goal is to extend the detection capabilities of EOS to encompass the important amide bands that characterize many important proteins. This advancement could provide critical insights into a person's biological state and potentially revealing the early development of various diseases.

As we continue to unravel the secrets of light through electro-optic sampling, we stand on the brink of a new era in medical diagnostics and material science. The ability to peer beneath the surface of light and uncover its wavy nature may not only enhance our understanding of the universe but also pave the way for innovations that could transform healthcare as we know it. There will certainly be ups and downs along the way, but the future is bright.

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attoworld.de/fris

feature

a year of utmost intensity –

how recieving the Nobel Prize became a life-changing moment for Ferenc Krausz

november 26, 2024 // Dr. Veit Ziegelmaier



On the occasion of the awarding of the Nobel Prizes in Physiology & Medicine and Physics to Katalin Karikó and Ferenc Krausz on December 10, 2023, the Chain Bridge, one of the landmarks of Budapest, was illuminated in the national colors of Hungary. Photo: Budapest Brand Nonprofit Zrt.

There are few events that can turn life upside down almost overnight — and winning a Nobel Prize is certainly one of them. Ferenc Krausz, one of the three laureates of the 2023 Nobel Prize in Physics, knows this all too well. While Krausz's schedule was already packed as a leading figure in attosecond physics, the announcement of his award in October 2023 catapulted him into the public eye like never before. The following months brought an avalanche of interview inquiries, invitations to conferences, congratulations, and even autograph and video message requests from all over the world. With only 24 hours in a day, his time for rest became much, much shorter.

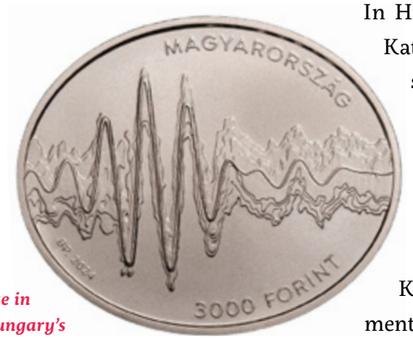
Suddenly, Krausz's research and that of his team was no longer confined to the specialized circles of the scientific community. The public, most of whom had likely never heard of attosecond pulses-ultrafast flashes of light used to measure electrons, the fastest movements outside the atomic nucleus — was now intrigued by the groundbreaking work that earned him the prestigious award. His work in attosecond science is not only crucial for fundamental research but also plays a promising role in the field of early disease detection, as aimed by the Center for Molecular Fingerprinting (CMF) in Hungary, where Krausz serves as the scientific director.

And if, like Krausz, you also have two nationalities (Hungarian and Austrian) and are doing your research in Bavaria, Germany, then you will be honored on even more sides. Even before the official Nobel ceremony in December 2023, Krausz was invited to talks in Europe like Belfast, Warsaw, and Berlin, among other cities. After receiving solemnly, the award from the Swedish Royal Family in Stockholm, he embarked on a lecture tour of Sweden, visiting Uppsala, Umeå, Gothenburg, and Lund. His travels didn't slow down in 2024, with invited talks across North America, including stops at prestigious universities like the University of Southern California, Stanford, and Berkeley. Krausz also visited several major Chinese cities — Shanghai, Beijing, Wuhan, and Changsha — to give talks and foster scientific collaborations.



Honors have continued to pour in from various quarters. In Bavaria, where Krausz conducts research at the Max Planck Institute for Quantum Optics and LMU Munich, he was awarded the prestigious Maximilian Order for Science and Art, the highest distinction the state can bestow. Photo: Thorsten Naeser

Honors have continued to pour in from various quarters. In Bavaria, where Krausz conducts research at the Max Planck Institute for Quantum Optics and Ludwig-Maximilians-Universität München, he was awarded the prestigious Maximilian Order for Science and Art, the highest distinction the state can bestow. In Austria, where Krausz holds citizenship and did some of his most groundbreaking research at TU Wien, he received the Grand Decoration of Honour in Gold with Sash from President Alexander Van der Bellen. His native Hungary also celebrated him with its highest state honor, the St. Stephen's Order.



Due to the Nobel Prize in Physics Hungary's National Bank minted a special silver coin featuring Ferenc Krausz portrait.
Photo: Magyar Nemzeti Bank

In Hungary, Krausz shares a unique status together with Katalin Karikó, the 2023 Nobel laureate in Medicine. Both scientists have become national icons, with Budapest even lighting up its famous Chain Bridge in the national colors to celebrate their achievements on the 10th of December, the day both recieves the Nobel Prize in Stockholm. To commemorate their success, Hungary's National Bank also minted a special silver coin featuring Krausz and Karikó's portraits. Their impact is so monumental that a mural featuring both scientists now adorns a prominent wall in Budapest.

At CMF, under Krausz's leadership, significant strides have been made. In early 2024, Hungary's first laser and biolab was established at ELI-ALPS in Szeged, where blood samples from the H4H study are being analyzed. This milestone was celebrated during the CMF Summit 2024, which featured lectures from three Nobel laureates: Katalin Karikó, Ferenc Krausz, and Gérard Mourou.

Among the many honors, one personal gesture stood out for Krausz — his team reached out to the U.S. sportswear brand Newton to create a custom running just for him. As a passionate runner, Krausz now owns a one-of-a-kind jogging featuring the iconic attosecond streaking trace and a reference to the 91 attoseconds, the shortest light pulse ever recorded by him and his group in Vienna at the time. In the future, these will motivate Krausz, like the ancient Greek messenger god Hermes, who wore winged sandals, to reach his goals even faster. It allows him one more time not to follow in the footsteps of others, but to create his own path.



As a passionate runner, Krausz now owns a one-of-a-kind jogging shoe featuring the iconic attosecond streaking trace.
Photo: Thorsten Naeser



A mural featuring the Hungarian Nobel Laureates Katalin and Krausz now adorns a prominent wall in Budapest.
Photo: Márk István Gruber

the legendary attochamber in the Nobel Prize Museum

october 15, 2024 // Thorsten Naeser

Attosecond physics has found its way into the Nobel Prize Museum in Stockholm. A replica of the first measuring apparatus for generating individual attosecond flashes of light from 2001 can now be admired in the entrance area. The exhibit was made possible by the former team led by Nobel Prize winner Prof. Ferenc Krausz. His colleagues from the pioneering days of attosecond physics dug deep into their memories and created a perfect replica of the system using many important original parts.

While ultrafast physics has large experimental facilities today, its beginnings were rather modest in comparison. At the TU Wien, Ferenc Krausz and his team worked for many years until they succeeded in teasing out isolated flashes of light lasting around 650 attoseconds from a small box full of wires, mirrors and electronics.

The experiment was preceded by a prototype laser from the company FEMTOPOWER. The laser was an amplifier system that delivered pulses with a duration of 20 femtoseconds (fs) and a pulse energy of one millijoule at a repetition rate of one kilohertz. These laser pulses were broadened in frequency in a neon-filled hollow fiber and compressed to around five femtoseconds using chirped mirrors. When the light then hit neon atoms from a gas nozzle again, it excited their electrons. As soon as the excited electrons released their energy again, they in turn emitted flashes of light in the extreme ultraviolet spectrum of light (XUV).



But how was it possible to measure such short periods of time? The physicists came up with a new measuring technique for this purpose, which is also presented in the small box.

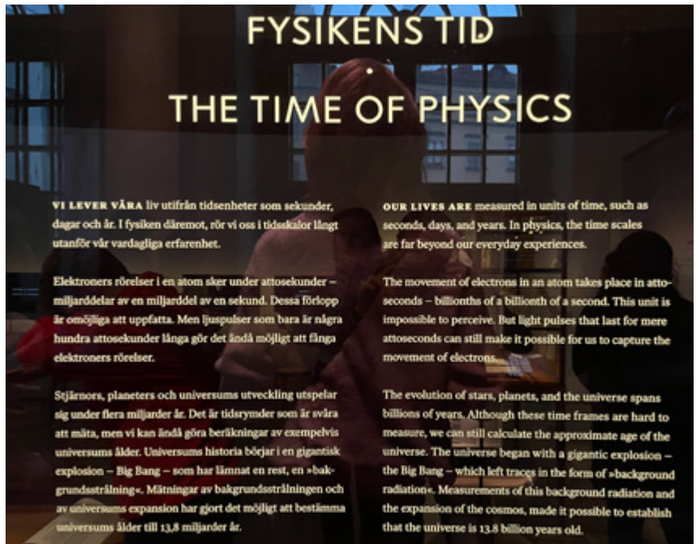
The heart of this time measurement apparatus was a multilayer double mirror. The mirror was divided into an inner and an outer section. The outer section reflected the laser pulse that had previously generated the XUV radiation, while the inner section reflected the newly generated XUV flashes of light. Both halves of the mirror could be shifted slightly against each other so that the incident light required different times to cover a distance due to the different distances.



With this double mirror, the laser pulse and the XUV light flash were focused on a sample, whereby the spatial offset of the two areas in the double mirror created a time delay between the two pulses. Electrons were released from the neon gas sample, which flowed out of a nozzle, by the XUV light flash (ionization), which now formed an electron pulse of the same duration as the attosecond light flash. This pulse was 650 attoseconds long and was detected by a time-of-flight spectrometer. By superimposing the ionization process with the field of the laser pulse, the time structure of the electron pulse and thus of the XUV light flash could be measured. The first measurement of a single attoscond light flash was successful.

Some important individual parts of the original measuring apparatus from 2001 have fortunately survived the decades. The rest of the system has now been added to from memory by the scientists who were involved in the pioneering experiments at the time and rebuilt for the museum. The curators in Stockholm are so enthusiastic about the exhibit that they have now decided to include the Attochamber in the permanent exhibition, despite the lack of space in the museum.

Our thanks for this wonderful project go to Prof. Reinhard Kienberger for his scientific and historical advice, Dr. Dmitrii Kormin for rebuilding the apparatus, Prof. Ulrich Heinzmann for providing the original mirrors, Prof. Andrius Baltuska for donating the original vacuum chamber and Dr. Michael Hentschel for collecting old components from the Viennese laboratories. They have succeeded in creating a wonderful memento of an eventful time and a groundbreaking discovery.



www.nobelprizemuseum.se

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.

CMF
CENTER FOR MOLECULAR FINGERPRINTING

the CMF complex: building on the scientific legacy of Hungary

november 29, 2024 // Markó Madaras

Hungary has long been a cradle of scientific innovation, home to world-renowned researchers and groundbreaking discoveries. The country's history is rich with contributions that have shaped modern science as it has produced many Nobel laureates, whose work continues to resonate globally. Continuing this proud tradition, Budapest will soon host the new building of the Center for Molecular Fingerprinting (CMF), a cutting-edge research facility designed to advance multidisciplinary science. The CMF Complex is a natural evolution of Hungary's rich scientific heritage, combining modern infrastructure with a legacy of excellence in research.



This is what the plans currently look like for the CMF Complex & the National Biobank on the Lágymányosi Campus in central Budapest.. Images: BUILDEXT



How can the future CMF complex be described?

The new CMF Complex is set to become a landmark for scientific research and innovation in Budapest, representing a next-generation facility designed to advance multidisciplinary scientific endeavors. The state-of-the-art building will include laser laboratories for measurements and development, biological laboratories, medical examination rooms for blood draws, modern offices, and operational units essential for long-term success.



A standout feature of the Complex will be the National Biorepository, which incorporates cryogenic biological sample storage as its cornerstone. Unlike the common –80°C storage systems many academic institutions use, this facility will preserve samples at an ultra-low temperature below –150°C. Automated reception and retrieval systems will enhance efficiency, making the biorepository a unique resource in the region.

By integrating diverse but complementary facilities, the CMF Complex will foster collaboration and innovation, enabling researchers to achieve breakthroughs in science and technology.

What is CMF's aim with the new building infrastructure?

CMF aims to establish the building as a leading hub for innovation and science, not only in Hungary but on a European scale. By providing cutting-edge infrastructure and fostering interdisciplinary collaboration, the facility will support researchers in tackling some of the most pressing challenges. One of our goals is to position Hungary as a des-

tination for world-class scientific talent and investment. Additionally, the building reflects CMF's commitment to creating a collaborative ecosystem where academia, industry, and government come together to drive impactful research and translate it into real-world applications.

When and how was the idea for the new CMF Complex conceived?

The idea for the CMF Complex was born from the need to centralize CMF's diverse operations, which are currently spread across Budapest, Szeged, and Garching. We recognized that consolidating these activities into a single, modern facility would boost efficiency and create a hub for outstanding research. The concept was further inspired by the potential to elevate Hungary's scientific capabilities. Early planning highlighted the importance of incorporating advanced laboratories and a state-of-the-art biorepository, paving the way for a facility that promotes long-term innovation. The early concepts gained momentum, solidifying the vision for a project that would shape Hungary's scientific landscape for decades to come.

At what stage are the preparations currently?

Preparations for the CMF Complex are making steady progress. The architectural designs and the first stage of technical blueprints for the laboratories and biorepository are nearing completion, ensuring that the facility meets the specific needs of researchers. Simultaneously, CMF's project team is optimizing the construction process to maintain alignment with the proposed timeline. Site preparations, including substructure engineering, are scheduled to begin in 2025, marking a significant step forward in the project's development. These efforts underscore CMF's commitment to turning its ambitious vision into reality. CMF's commitment to turning its ambitious vision into reality.



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Center for Molecular Fingerprinting

CMF's Nobel Symposium at Szeged

June 17, 2024 // Dr. Veit Ziegelmaier

June 17th marked another milestone for ATTOWORLD's cooperation institute The Center for Molecular Fingerprinting (CMF). In Szeged's impressive ELI Alps Research Center, CMF's first laboratory in Hungary was inaugurated, which is now equipped with the innovative laser system Infrasampler 1.5 to measure the blood samples of the H4H study in the future.



Three Nobel Prize winners spoke at the CMF Summit 2024: Gérard Mourou, Katalin Karikó and Ferenc Krausz. In their midst Mihaela Žigman, CMF Research Director.
Image: Dr. Veit Ziegelmaier

Numerous guests from politics and science attended the event, that was accompanied by a top-class Nobel symposium, moderated by CMF's Research Director Mihaela Žigman, Three Nobel laureates, namely Ferenc Krausz (2023 Physics), Katalin Karikó (2023 Medicine) and Gérard Mourou (2018 Physics), who are closely associated with the ELI APLs research institution, gave insights into their current research in their lectures.

Ferenc Krausz, CMF' Scientific Director, started off as host. In his lecture "sub-atomic motions of electrons initiated, controlled and captured by light" he traced the path from the detection of electrons in motion in the range of attosecond physics to the application of this basic research in terms of early diagnosis of diseases, as CMF does with the measurement of molecular fingerprints.

Katalin Karikó reported in an inspiring and engaging manner on the focus of her research which have fundamentally changed the understanding of how mRNA interacts with the human immune system and contributed to the rapid vaccine development during the corona pandemic.

Gérard Mourou then talked in his presentation "a passion for extreme light" about his work with ultra-short, high-intensity laser pulses that reach into the petawatt range. Inspired by so much concentrated knowledge, the guests left the lecture hall delighted. It is certainly not often that you can listen to three Nobel Prize winners in a row.

Here you can watch the presentations by the three Nobel Prize winners on YouTube:



“An important next milestone is the temporal characterization of relativistic isolated attosecond electron bunches.”

[Prof. László Veisz]

october 18, 2024 // Thorsten Naeser

In a festive ceremony in October 2024, Ferenc Krausz and Anne L’Huillier were appointed honorary doctors at the Faculty of Science and Technology, at Umeå University in the middle of Sweden. Both researchers have strong links to the University through collaborations and mentoring. The ATTOWORLD-team still has a close connection with Prof. László Veisz Laser physicist at Umeå University and former colleague at the Max Planck Institute of Quantum Optics. László is also a pioneer of attosecond physics. Reason enough to find out from László what laser research looks like under the Arctic Circle. Here, László talks about his projects, Santa Claus, and reveals the real reason why Ferenc received an honorary doctorate from Umeå University.

How did it come about that Ferenc received an honorary doctorate from Umeå University?

Honestly, I’ve always wanted to see Ferenc in a penguin suit in real life … but, of course, the fact that some of my activities were originally initiated by Ferenc also played a role in this decision. Our lab, the ‘RElativistic Attosecond physics Laboratory’ (REAL), and the associated research activities are important parts of the Department of Physics as well as Umeå University. This is the reason in combination with the Nobel Prize, which highlighted the significance of this work, and the widely recognized visit of Ferenc in Umeå after the Nobel ceremony last year. Moreover, potential future cooperation between some local biobanks and Ferenc, have further strengthened the case.

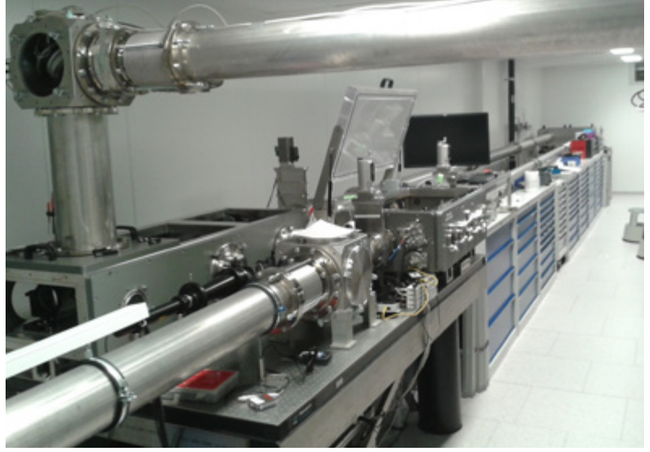
Is there still collaboration between the ATTOWORLD group and your research team?

After completing the initial joint works in ultrashort physics in Germany in 2016, we later published the results with several members of ATTOWORLD. Thereafter, Ferenc mostly worked on the new topic of molecular fingerprinting, which did not overlap much with our ongoing work. However, there are ideas that we discuss which could lead to new collaborations.

What are your main areas of research at the moment?

My current research focuses on the generation of intense near-single-cycle light fields and their utilization in attosecond and laser-plasma physics to produce and apply attosecond X-ray and electron pulses, such as XUV pump — XUV probe attosecond spectroscopy and laser and nanoplasma interaction. Nanophotonics is a newly started research field in our group utilizing few-fs laser pulses. The laser development has been mostly finished. Though, as the first law of laser development says: ‘A laser development is never ready’, so it has been ‘mostly’

life within attoworld



finished. An important next milestone is the temporal characterization of relativistic isolated attosecond electron bunches. We know that they are there from nanotips, but it is challenging to measure their duration.

Is there a highlight from your research group that can be read in a paper?

One very important milestone has recently been achieved, the laser reached its final form with 100 TW peak power 4.3 fs duration and, most importantly, waveform stabilization. These new results are under publication, but if you want to read a paper with general relevance, I recommend a surprising publication. It is about how to generate shorter pulses than the Fourier limit that we used to shorten the laser pulses below 4 fs. You will find the link to the original publication at the end of the interview.

Sweden tends to be a dark place in winter. How do you get used to the winter cold and darkness?

It should be noted that Umeå is located just above the midpoint of Sweden, though still well below the Arctic Circle, meaning it’s far in the North. First, for half a year the days are longer here than in the south, which is fun with the sun at almost midnight. In winter, I do not see much difference: when I wake up, there is light and when I finish working, it is dark. In fact, the snow, which is typical between December and March, makes the nights also brighter than in the southern parts of Sweden or most of Europe. Not to speak about the northern lights. Regarding the temperatures: There is no bad weather, just bad clothing. The typical temperature in winter is between 0 and –15 C. Temperatures colder than this are rare. It is ideal for cross-country skiing that you can do at many places in and around Umeå. I need five minutes from home to get to the nearest trail. The only drawback if it is cold that you don’t want to stay too long on the Christmas market.

Santa Claus probably lives not far away from you, somewhere in Lapland. How is Christmas celebrated in the far north?

The Finns have a monopoly on Santa Claus. It is scandalous! We are already working on a solution … Really great is the generalization of the Swedish buffet at Christmas, which is called ‘julbord’. There is a great variety of food that you can enjoy. If you are not a big fan of fish as food, you will become one after a julbord. It should be noted that the midsummer (21 June) is as important a celebration as Christmas.

original publication:

utilizing the temporal superresolution approach in an optical parametric synthesizer to generate multi-TW sub-4-fs light pulses

AUTHORS: A. Muschet, A. De Andres, P. Fischer, R. Salh & L. Veisz

JOURNAL: ***Optics Express* 30**, 4374 (2022)

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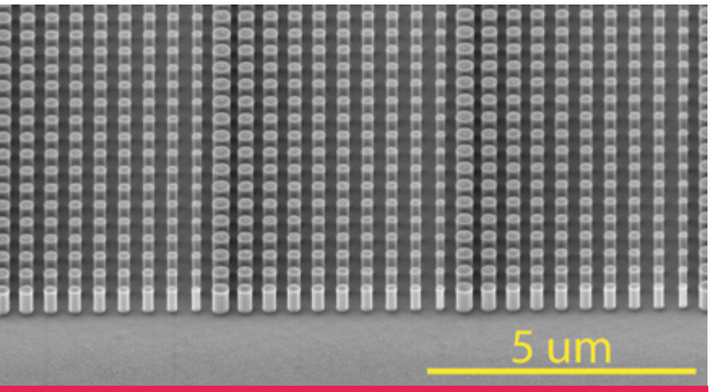
doi.org/10.1364/OE.447846

alumni

it's a match optical – metasurfaces and ultrafast science

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

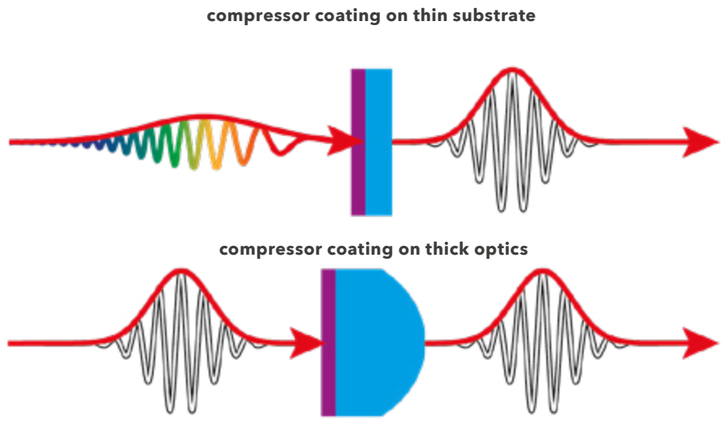
Catapulted by the increasing availability of nanofabrication, optical metasurfaces are revolutionizing applied optics by combining the best from Fresnel lenses, phased arrays, waveguides, and Mie scattering. To manufacture a metaoptics – instead of molding, grinding, and polishing glass — Marcus Ossiander, 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

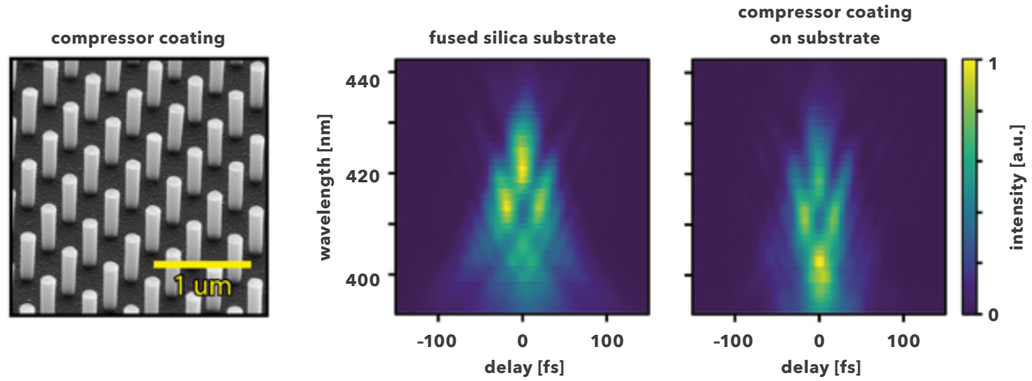
As long as two adjacent nanostructures are spaced by less than the wavelength of the light, an incoming light wave experiences the structure ensemble as a slowly changing material rather than many individual structures. Consequently, metaoptics (although similar in appearance to two-dimensional gratings) 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].



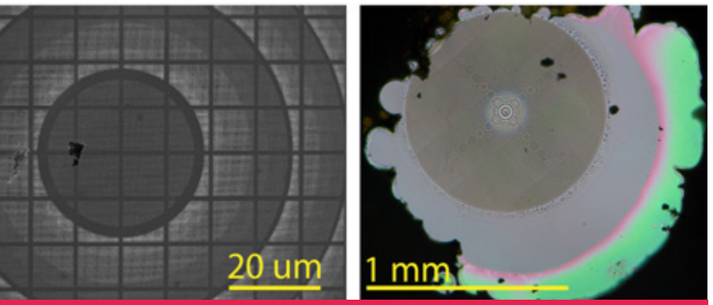
Realization of a compressor coating. Left: a metamaterial manufactured to compress ultrafast titanium-sapphire laser pulses. Right: FROG measurements of a laser pulse transmitted through a bare glass substrate and the same substrate with the coating applied show a pulse compression from 48 to 37 femtoseconds.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

alumni

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.

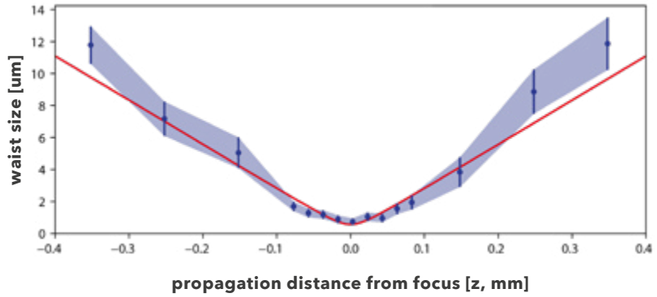
Metasurfaces –often thousands of times thinner than classic optics– seem predestined to solve this absorption issue. However, metasurfaces usually comprise nanostructures with high refractive indexes that mold the phase of transmitted light. High refractive indexes do not exist in the extreme ultraviolet 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].



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

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.

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.



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.

[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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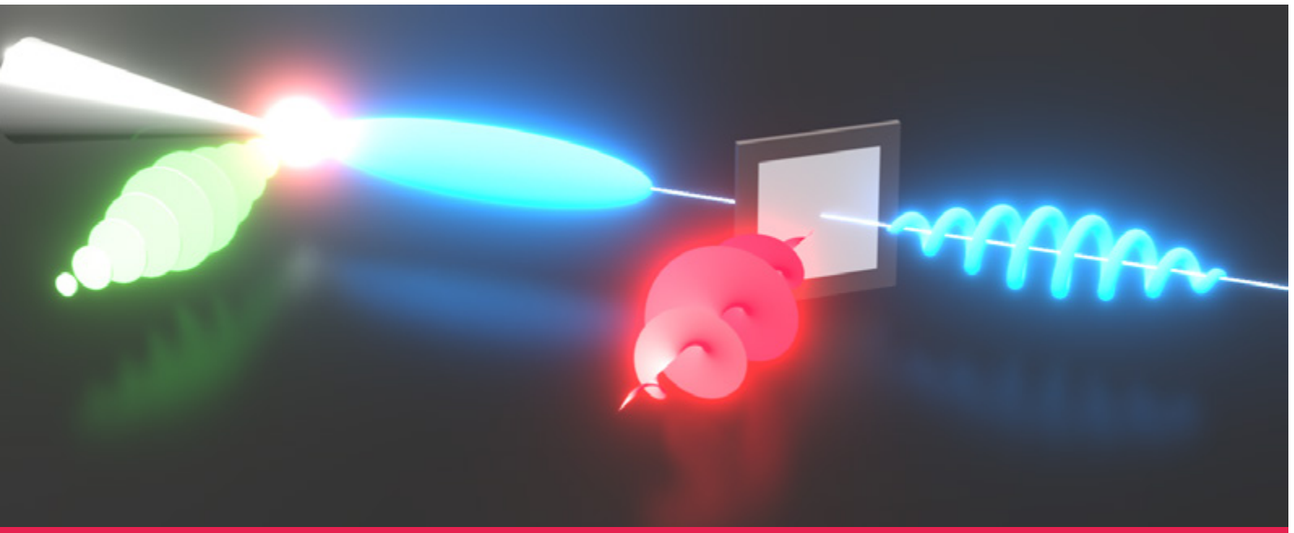
www.attosecondmetaoptics.com

structured electrons with chiral mass and charge

september 13, 2024 // AG Baum – light and matter

Have you ever placed the palm of your left hand on the back of your right hand, in such a way that all fingers point in the same direction? If you have, thenyou probably know that your left thumb will not touch its right counterpart. Neither rotations nor translations nor their combinations can turn a left hand into a right hand and vice versa. This feature is called chirality.

Scientists of the Light and Matter Research Group around Prof. Peter Baum from the Department of Physics at the University of Konstanz have now succeeded to imprint such a three-dimensional chirality on the wave function of a single electron. They used laser light to shape the electron's matter wave into left-handed or right-handed coils of mass and charge. Such engineered elementary particles with chiral geometries other than their intrinsic spin have implications for fundamental physics but may also be useful for a range of applications, such as quantum optics, particle physics or electron microscopy. "We are opening up new potentials for scientific research that have not been considered before," says Peter Baum.



Schematic of the experiment on the deformation of electrons into chiral spiral forms. Image: Dr. Yiqi Fang, University of Konstanz

Chirality of single particles and composites

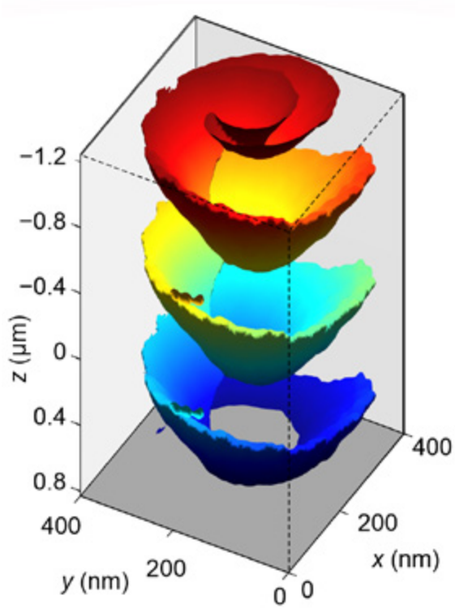
Chiral objects play a crucial role in nature and technology. In the realm of elementary particles, one of the most important chiral phenomena is spin, which is often compared to a self-rotation of a particle, but is in fact a purely quantum-mechanical property with no classical analogue. An electron, for example, has a spin of one-half and therefore often exists in two potential states: a right-handed and a left-handed one. This fundamental aspect of quantum mechanics gives rise to many important real-world phenomena like almost all magnetic phenomena or the periodic table of the elements. Electron spin is also critical to the development of advanced technologies such as quantum computers or superconductors.

However, there are also composite chiral objects in which none of the constituents is chiral by itself. Our hand, for example, is composed of atoms with no particular chirality, but it is nevertheless a chiral object, as we have learned earlier. The same is true for many molecules in which chirality appears without the need for any chiral constituent. Whether a molecule is in the left-handed or in the right-handed geometry can make the differences between a healing drug and a harmful substance – both versions can have very different biological effects due to their different three-dimensional geometry. In materials science and nanophotonics, chirality influences the behavior of magnetic materials and metamaterials, leading to phenomena such as topological insulators or chiral dichroism. The ability to control and manipulate the chirality of composite materials composed of achiral constituents thus offers a rich knob to tune the properties of materials as required for applications.

How to induce geometrical chirality into a single electron

Is it possible to shape a single electron into a chiral three-dimensional object in terms of charge and mass? In other words: Can we induce chirality in an electron without the need for spin? So far, researchers have only moved electrons along spiral trajectories or created electron vortex beams in which the phase of the de Broglie wave rotates around the center of the beam at constant charge and mass. In contrast, the chiral matter wave object that the Konstanz physicists report in their Science paper has a flat de Broglie wave but the expectation values of charge and mass are shaped into a chiral form.

To create this object, they used an ultrafast transmission electron microscope and combined it with laser technology. The researchers first generated femtosecond electron pulses and then shaped them into chiral patterns by interacting with precisely modulated laser waves with spiral electric field. Normally, electrons and laser photons do not interact in such an experiment, because energy and momentum cannot be conserved. However, silicon nitride membranes, which are transparent



Measuring chiral matter waves with attosecond electron microscopy (left and right).
Images: Dr. Yiqi Fang, University of Konstanz

to the electrons but change the phase of the laser light, facilitated the interaction in the experiment.

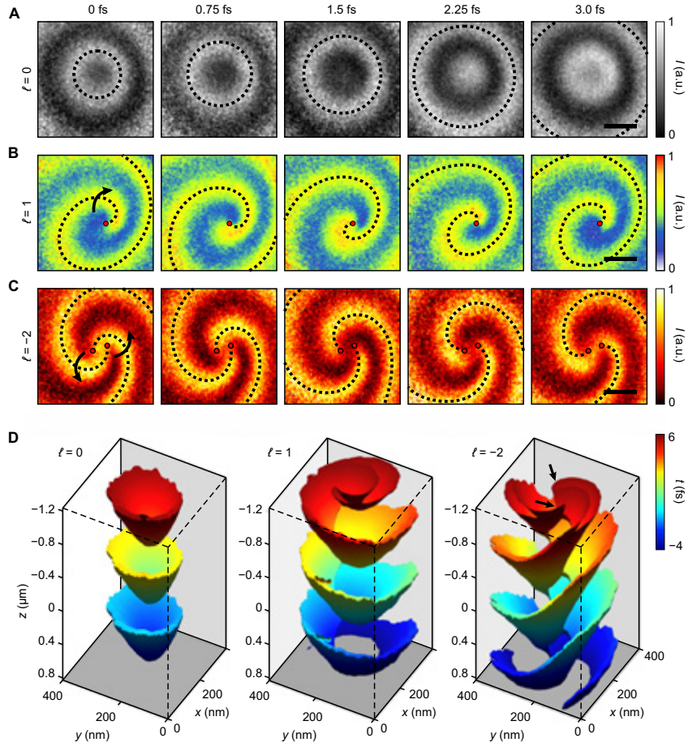
The spiral electric fields in the laser wave either accelerated or decelerated the incoming electron around the center of the beam, depending on azimuthal position. Later in the beam, the accelerated or decelerated electrons eventually caught up with each other, and the wave function was transformed into a chiral coil of mass and charge. "We then used attosecond electron microscopy to obtain a detailed tomographic measurement of the electron's expectation value, that is, the probability of being somewhere in space and time," says Baum, explaining the way with which they measured their generated shapes. Right or left-handed single or double coils appeared in the experiment. Neither spin nor angular momentum nor spiral trajectories were needed to produce this purely geometrical chirality.

To investigate whether an interaction of three-dimensional electron coils with other chiral materials would preserve chirality, the researchers put gold nanoparticles with chiral electromagnetic fields into their electron microscope and used the chiral electron coils to measure the scattering dynamics. Depending on whether the researchers fired a left-handed electron at a right-handed nanophotonic object or the other way round, the results showed constructive or destructive rotational interference phenomena. In a sense, the overall chirality never disappeared.

A whole new world of possibilities

The ability to shape electrons into chiral coils of mass and charge opens new avenues for scientific exploration and technological innovation. For example, the engineered chiral electron beams should be useful for chiral electron-optical tweezers, chiral sensor technologies, quantum electron microscopy or for probing and creating rotational motion in atomic or nanostructured materials. In addition, they will contribute to general particle physics and quantum optics.

"Although we have so far only modulated the electron, one of the simplest elementary particles, the method is general and applicable to almost any particle or matter wave. What other elementary particles have or can have such chiral shapes, and are there possible cosmological consequences?" says Baum. Their next step is to use their chiral electrons in attosecond electron imaging and two-electron microscopy, in order to further elucidate the intricate interplay between chiral light and chiral matter waves for applications in future technologies.



original publication:

structured electrons with chiral mass and charge
AUTHORS: Y. Fang, J. Kuttruff, D. Nabben & P. Baum
JOURNAL: ***Science* 385 (6705)**, 183–187 (2024)

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www.science.org/doi/abs/10.1126/science.adp9143

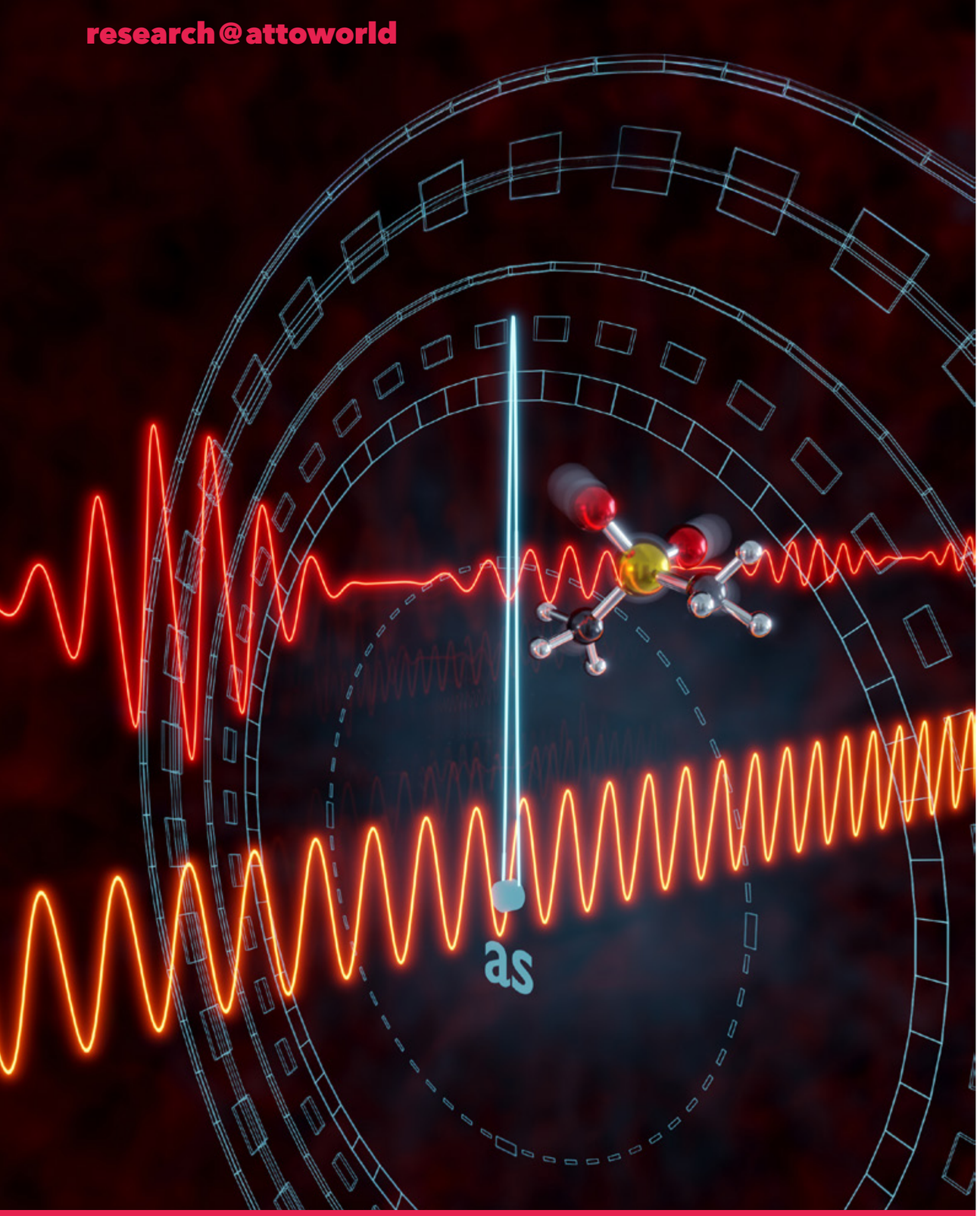


Figure 1: Concept of electro-optic delay tracking (EODT). In a spectroscopic measurement, the electric-field of an infrared pulse exciting molecular vibrations of a dimethyl sulfone sample (top) is recorded with electro-optic sampling. This involves scanning the delay between the waveform to be sampled and a gate pulse (blue). In a dual-oscillator experiment, timing jitter of the laser synchronization leads to error in the delay axis. A second narrowband reference waveform with known carrier frequency is sampled simultaneously by a fraction of the same gate pulses, providing calibration of the delay axis in post processing.
Image: RMT.Bergues

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dual-oscillator field-resolved infrared spectroscopy with attosecond precision

november 12, 2024 // field-resolved infrared spectroscopy

Electro-optic sampling of infrared electric fields has set sensitivity and dynamic-range records in broadband molecular vibrational spectroscopy [1,2]. We introduced dual-oscillator-scanning acquisition with electro-optic delay tracking (EODT) to record highly reproducible electro-optic sampling traces at kilo-Hertz acquisition rates.

Typical acquisition in an electro-optic sampling measurement requires — similar to many other time-domain experiments- the delay scan of a gate pulse with respect to the infrared waveform, commonly achieved by moving a mechanical translation stage. As a result, acquisition in such experiments takes normally at least around one second, during which intra-scan noise accumulates. By using a modulated repetition-frequency lock between two laser oscillators for scanning[3], we could speed up electro-optic sampling measurements to 2,800 mid-infrared waveforms per second. While being highly versatile, such delay scanning with two synchronized lasers has up to now been limited in timing precision by the electronic jitter of the frequency lock. We mitigated this limitation by introducing a calibration for the delay of the measured signal on the level of individual laser shots. The new technique, electro-optic delay tracking (EODT), samples a known and highly reproducible infrared reference waveform simultaneously with the spectroscopic measurement (Fig. 1). This reference provides precise post-processing calibration of the delay axis, achieving attosecond-level precision.

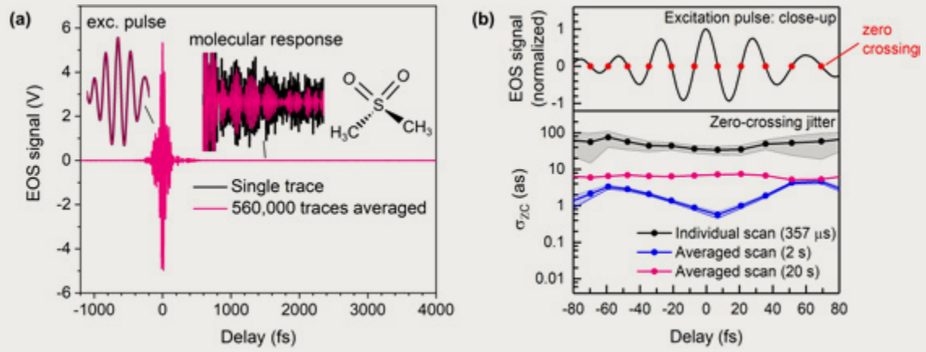


Figure 2: Delay calibration with EODT allows to record highly reproducible infrared waveforms at kilo-Hertz acquisition rates. (a) Demonstration of the reproducibility of infrared waveforms recorded with electro-optic sampling and EODT with a measurement of dimethyl sulfone ($DMSO_2$) as a test substance. Delay calibration allows averaging directly in time domain, revealing the molecular response of $DMSO_2$. (b) Characterization of the waveform reproducibilility with EODT by the standard deviation of the zero-crossing points of the measured signal, σ_{zc}, for different averaging times.

As a demonstration for the reproducibility achieved in dual-oscillator measurements with EODT, Fig. 2a shows consistent field-resolved measurements of a dimethyl sulfone (DMSO2) sample over 200 s of acquisition time. Averaging the 560,000 single scans recorded in this time interval reveals details of the molecular response following the infrared excitation pulse, without any deterioration of the signal shape. The waveform reproducibility is quantified in Fig. 2b by the standard deviation of the zero crossing points of the excitation-pulse signal, σ_{zc}. The obtained delay jitter is only 50 attoseconds, when comparing single scans, and reaches single-digit attosecond precision upon averaging.

Possible applications of precision electro-optic sampling with high acquisition speed range from the real-time tracking of reaction dynamics to label-free flow-cytometry. The modulated dual-oscillator approach to scanning delay ranges of several picoseconds at kilo-Hertz rates is directly applicable to many other ultrafast condensed-phase experiments such as pump-probe, coherent anti-Stokes Raman, and photon echo spectroscopies. Up to now, timing jitter of laser synchronization in the scheme made it impossible to reach sufficient reproducibility for femtosecond-resolved measurements. The new calibration method of EODT now provides attosecond precision for the delay axis of each scan, making dual-oscillator scanning measurements highly reproducible in time domain and widely applicable.

[1] **field-resolved infrared spectroscopy of biological systems**
AUTHORS: I. Pupeza et. al
JOURNAL: ***Nature* 577**, 52 (2020)

[2] **direct sampling of electric-field vacuum fluctuations**
AUTHORS: C. Riek et al.
JOURNAL: ***Science* 350**, 420 (2015)

[3] **all fiber-coupled THz-TDS system with kHz measurement rate based on electronically controlled optical sampling**
AUTHORS: R. Dietz et al.
JOURNAL: ***Optics Letters* 39**, 6482 (2014)

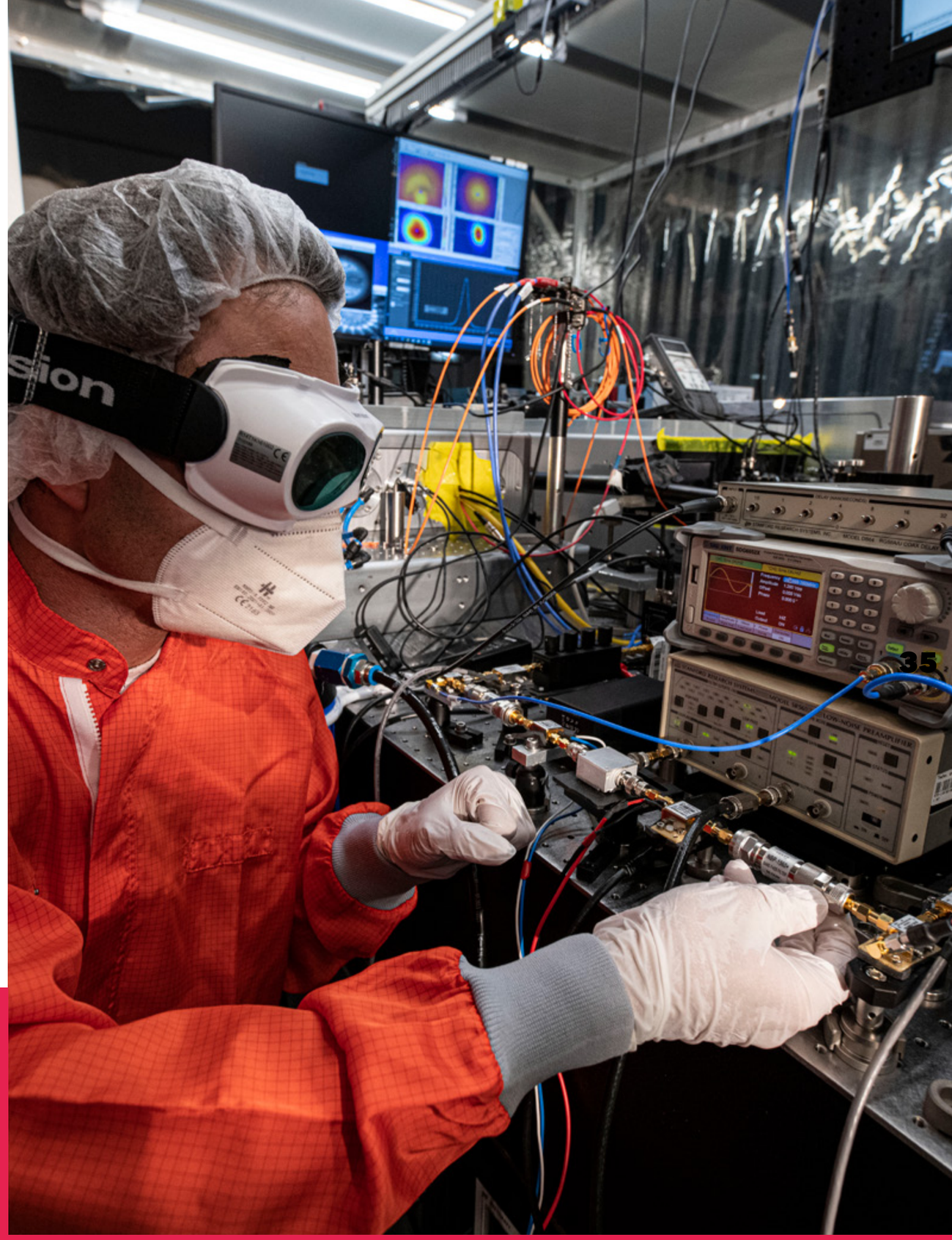
original publication:

dual-oscillator infrared electro-optic sampling with attosecond precision
AUTHORS: A. Weigel, P. Jacob, W. Schweinberger, M. Huber, M. Trubetskov, P. Karandušovský, C. Hofer, T. Buberl, T. Amotchkina, M. Högner, D. Hahner, P. Sulzer, A. Leitenstorfer, V. Pervak, F. Krausz & I. Pupeza
JOURNAL: ***Optics Express* 30**, 4374 (2022)

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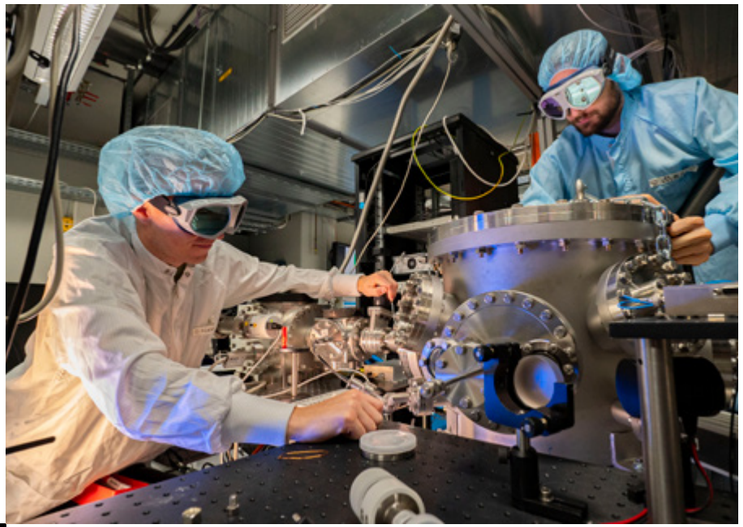
A modulated electronic repetition-frequency synchronization of two laser oscillators provides the basis for electro-optic sampling with kilo-Hertz scan rates. The electronic jitter is compensated in post-processing using calibration with electro-optic delay tracking (EODT). Photo: Thorsten Naeser

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HORUS for versatile experiments

october 29, 2024 // field-resolved nano spectroscopy

Our attosecond beamline infrastructure is currently undergoing a major overhaul, since our new high-power state-of-the-art SWIR laser system HORUS (High-power OPCPA system for high Repetition rate Ultrafast Spectroscopy) is now fully in operation. HORUS provides ultra-short 25 fs laser pulses at 10 kHz repetition rate and with up to 5 mJ of pulse energy, which is equivalent to an average power of 50 W available for experiments and our attosecond and XUV beamline systems.





HORUS beamline at the laboratory of attosecond physics at the Max Planck Institute of Quantum Optics.
Photos: Thorsten Naeser

Two new beamlines for attosecond and field sampling experiments have been set up so far. The HORUS SXR beamline consists of XUV generation using HHG in an argon gas target and a secondary IR bypass arm including a delay stage for pump-probe type experiments. The HHG has been tailored to accommodate the up to 10 times higher average power, compared to the original beamlines driven by Ti:Sapphire lasers. Furthermore, an active interferometric stabilization of the two beamline arms has been installed along with a CEP stabilization system of the pump laser, leading to a residual CEP noise below 100 mrad. XUV photon energies of up to 220 eV have been generated successfully with the current setup.

Our newest addition to our attosecond infrastructure is a high-power stretched capillary fiber, capable of spectrally broadening and compressing the mid-IR pulses from our HORUS laser down to the single-cycle regime. So far, ultra-short MIR pulses with a duration of 13 fs, corresponding to less than two optical cycles, have been generated with several mJ of pulse energy.

Our new beamline infrastructure will facilitate versatile experiments reaching from transient-reflection studies, core level spectroscopy of atoms and molecules or X-ray driven current generation to field-sampling. Furthermore, experiments on generating optical vortices with radial or azimuthal polarization are planned in order to generate extremely strong magnetic fields for magnetic field sampling applications. is currently under development.

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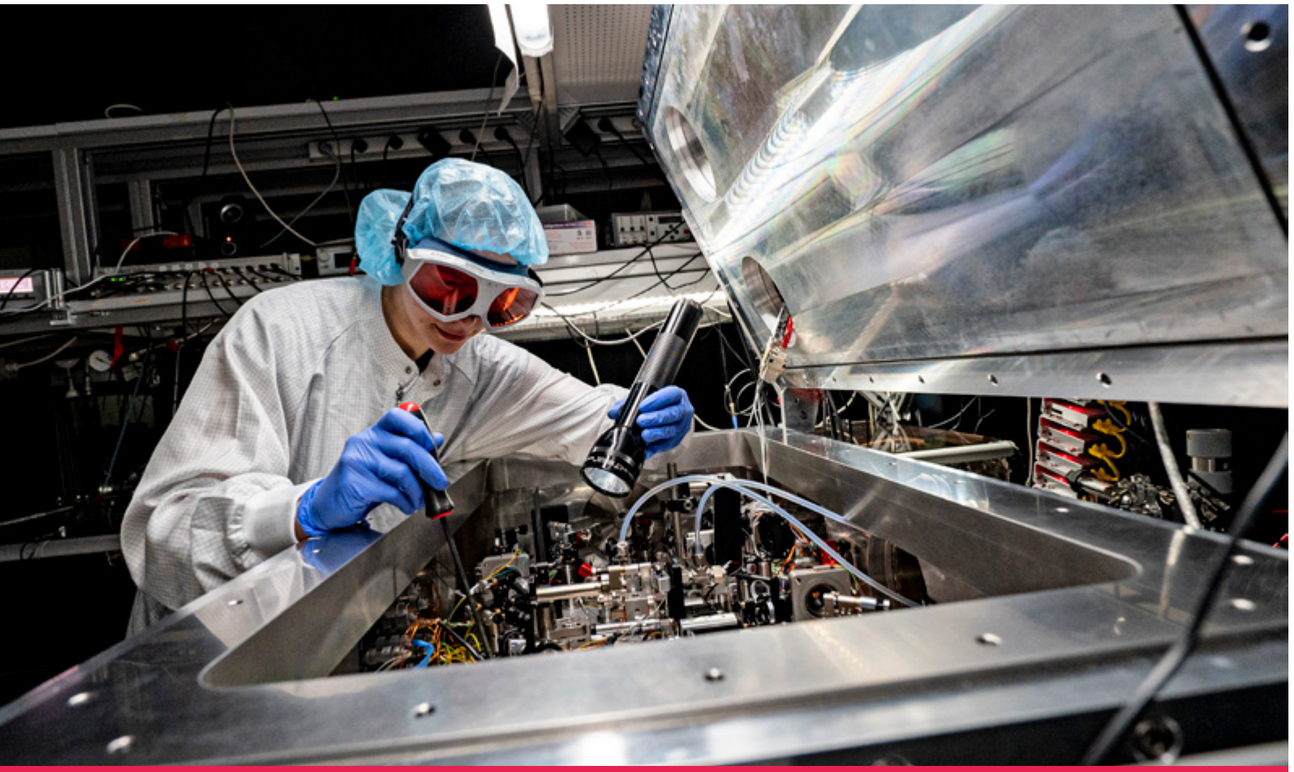
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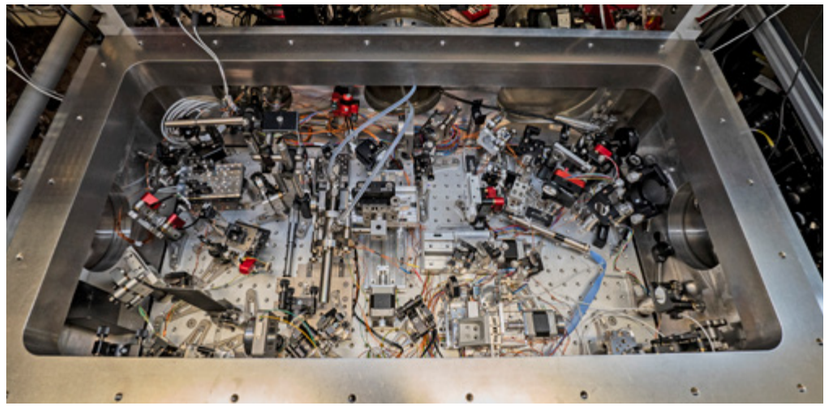
harnessing soliton dynamics for attosecond pulse generation in the deep ultraviolet

october 18, 2024 // attosecond spectroscopy 2.0

Attosecond science has revolutionized our ability to observe ultrafast electron dynamics. However, pushing the boundaries of attosecond pulse generation into the deep ultraviolet (DUV) has remained a challenge. Our recent research focuses on a novel approach to generate these ultrashort DUV pulses, opening up exciting possibilities for exploring electron dynamics in molecules and materials where valence electron excitations are prominent.



Amelie Heinzerling working on the setup where the produced the shortest laser field transients ever recorded.
Photos: Thorsten Naeser



Our work leverages the phenomenon of soliton self-compression in gas-filled hollow-core fibers. By carefully controlling the parameters of the laser pulses, the gas, and the fiber, we can generate solitons — self-sustaining wave packets that maintain their shape as they propagate. When several solitons are simultaneously excited and experience negative dispersion as well as self-steepening, we can observe extreme self-compression. Perturbations such as third-order dispersion can lead to the emission of resonant dispersive waves (RDWs) in the DUV region, resulting in visible-UV attosecond transients at the fiber output.

As part of her PhD project, Amelie Heinzerling used a technique called nonlinear photoconductive sampling (NPS) to directly measure the electric field of these ultrashort pulses, a feat rarely achieved in the DUV region. This allows for their precise characterization and opens the door to future field-resolved measurements.

The generation of attosecond DUV pulses via soliton dynamics is a significant advance in ultrafast science. This research paves the way for exploring uncharted territories in attosecond physics, promising to deepen our understanding of the universe at the most fundamental level.

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The cover image symbolizes the illumination of a blood drop, revealing a unique molecular fingerprint that correlates with diverse health states. Cover image: Sama Aljarhi (www.samaalj.com)

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a drop of blood, many diagnoses: infrared spectroscopy for rapid health screening

june 28, 2024 // broadband infrared diagnostics

Using infrared light and machine learning, researchers have developed a method to effectively screen human health and its deviations at a population level.

Infrared spectroscopy — a technique that analyzes the molecular composition of substances using infrared light — has long been a cornerstone in chemistry, providing molecular "fingerprints" through measurement devices called spectrometers. When applied to complex biofluids like blood plasma, it reveals detailed molecular information, making it a promising tool for medical diagnostics. Despite its potential, the value of infrared spectroscopy has not been sufficiently recognized and has not been adopted in clinical settings.

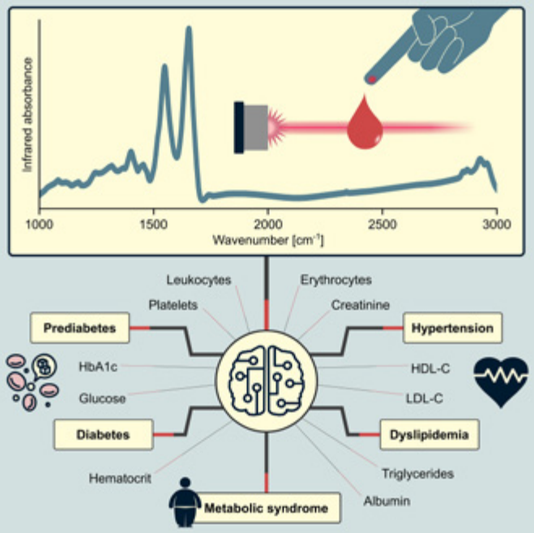
Addressing this gap, the BIRD-group at LMU and MPQ, led by Mihaela Žigman, partnered with Annette Peters' team from Helmholtz Munich. They applied infrared molecular fingerprinting to a diverse population by analyzing blood samples from thousands of participants in the KORA study — a large-scale health research project in Augsburg, Germany, involving randomly selected adults who underwent medical examinations and blood donations.



Tarek Eissa, the study's lead author, and Mihaela Žigman, the senior author, from the BIRD-team. Photo: Thorsten Naeser

Over 5,000 blood plasma samples were measured using Fourier Transform Infrared (FTIR) spectroscopy. Researchers Tarek Eissa and Cristina Leonardo obtained molecular fingerprints from these samples and applied machine learning algorithms to correlate the spectral data with clinical health information.

The analysis revealed that these infrared fingerprints contain a wealth of information, enabling simultaneous screening for several



The approach pairs infrared spectroscopy with machine learning to reveal information about the molecular profile of blood plasma and ultimately detect physiological conditions via a single measurement. Illustration: Tarek Eissa

health conditions using a single measurement. Their machine learning models successfully distinguished multiple health states, including abnormal blood lipid levels, variations in blood pressure, type 2 diabetes, and even pre-diabetes — a precursor often undetected by standard methods. Remarkably, they could also identify that certain healthy individuals were likely to develop aberrations in their health state in the future.

This approach is significant for several reasons. First, in any random population, individuals are highly heterogeneous, and it's also challenging to pinpoint individuals without any health abnormalities due to their own inherent physiological changes over time. Second, many people suffer from multiple health conditions simultaneously, traditionally requiring separate medical tests to diagnose each condition. This new method accurately identifies a range of health issues in a single measurement. Moreover, it can do so in a highly cost-effective manner.

The study lays the groundwork for integrating infrared molecular fingerprinting into routine health screenings, allowing healthcare providers to detect and manage conditions more efficiently. This is particularly vital for metabolic disorders like cholesterol abnormalities and diabetes, where timely interventions can significantly improve patient outcomes. As the technology advances and its capabilities expand through further research and clinical studies, we could see even more health conditions added to its diagnostic repertoire.

original publication:

plasma infrared fingerprinting with machine learning enables single-measurement multi phenotype health screening

AUTHORS: T. Eissa, C. Leonardo, K. Kepesidis, F. Fleischmann, B. Linkohr, D. Meyer, V. Zóka, M. Huber, L. Voronina, L. Richter, A. Peters & M. Žigman

JOURNAL: ***Cell Reports Medicine* 5**, 101625 (2024)

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



Dr. Amelie Heinzerling

august 1, 2024 // attosecond spectroscopy 2.0

"Field-Resolved Single-Cycle Deep-UV Pulses via Attosecond Solitons"



Dr. Ritika Dagar

june 20, 2024 // attosecond spectroscopy 2.0

"Investigating Ultrafast Nanoscale Surface Dynamics using Reaction Nanoscopys"



Dr. Philip Jacob

february 6, 2024 // broadband infrared diagnostics

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









Photos: Thorsten Naeser, Dr. Veit Ziegelmaier & Nicole Buchwiser



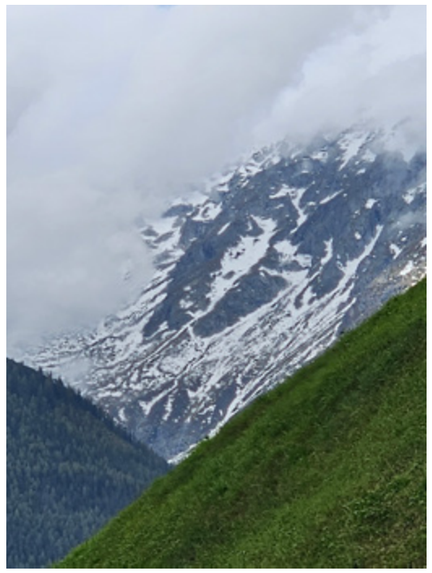


scaling new heights – the 2024 ATTOWORLD-retreat in South Tyrol

november 27, 2024 // Dr. Veit Ziegelmaier

For the third year running, this year's ATTOWORLD-retreat unfolded at the friendly Hotel Steinpent in St. Johann in Ahrntal, South Tyrol, a venue that is swiftly becoming a cherished tradition. Surrounded by a lovely mountain scenery, this internal science summit brought together all ATTOWORLD-research groups for an invigorating exchange of ideas in an awe-inspiring setting.

Each team leader shared their research journeys, charting both the rocky paths of challenges and the rewarding vistas of achievements. Much like scaling a towering mountain, their efforts have often involved steep climbs, yet many have reached critical milestones and are now forging ahead to new scientific heights. Under the steadfast guidance of Nobel Laureate Ferenc Krausz, the teams remain united in their ascent toward ambitious goals, driven by a shared determination to move mountains despite the sheer cliffs of work that lie ahead.



Evenings were reserved for poster sessions, lively discussions, and camaraderie over delicious meals, fortifying the bonds within the team. Midweek, the group took a well-earned pause for a day of hiking through the surrounding mountain trails. This interlude in nature mirrored their research endeavors — where perseverance transforms daunting climbs into rewarding progress, and every step upward reveals a clearer horizon. By the retreat's close, the participants had crested the summit of their specialist topics. As they descended back into the metaphorical valley and prepared for the journey home, a lighter atmosphere prevailed.

The final evening featured a live reading of Alice in Quantum Land, a playful yet insightful audio play by the school laboratory 'Photonlab' that introduces quantum physics to children and young people with charm and humor. This lighthearted final served as a refreshing reminder that even the steepest climbs can be tempered with moments of joy and creativity.







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.

physics with rubber bands and drops

october 18, 2024 // Jonas Hamp, Mihailo Macesic & Laura Schroeder

What do rubber bands, drops of water and small, sealed boxes have in common? They are all part of the physics problems that had to be solved at the physics championships in Europe. The marathon began with the Upper Bavarian regional competition of the German Young Physicists' Tournament (GYPT). As every year, it took place at the Max Planck Institute of Quantum Optics (MPQ). Laura Schroeder and Mihailo Macesic made it to the national and international competitions in Ulm, Bad Honnef and Leoben, Austria, with their prize-winning experiments at the MPQ. Here the two, together with Jonas Hamp, who supervised the competition at MPQ as a working student at PhotonLab, report on their experiences.



The Dachau regional competition was held at the Max Planck Institute of Quantum Optics at the beginning of the year. Dr. Silke Stähler-Schöpf, Dr. Andreas Kratzer, Yannik Pieper and I were supported on many levels in preparing for the competition by the institute's scientists, teachers from the region and the PhotonLab.

As a supervisor, I had an overview of all the tasks. I found the 'Shooting Rubber Band' problem particularly fascinating. Here, an ordinary rubber band is stretched and shot, with the subtle but important difference that if it is deformed unevenly before firing, it continues to fly. Despite this personal preference, the other tasks were in no way less interesting or challenging. I can only recommend any physics enthusiast to take part in the competition."

Jonas Hamp



Great pleasure at the award ceremony of the Upper Bavaria regional Championship of the German Young Physicists' Tournament (GYPT) on january 27, 2024 at the MPQ. Photo: PhotonLab

Three days and two nights in which I only slept for a total of eight hours: That's how long my adventure lasted, which began in early March when I had the chance to be one of the participants in the GYPT national round, which took place at the German Physical Society's center in Bad Honnef. As a student, the GYPT gives you the opportunity not only to gain an insight into the respective field of research, but also to tackle a scientific problem yourself. To work on the problem '02 Droplet Microscope', I used a drop of water as a lens in a microscope. Beforehand, I simulated the beam path of light through the droplet that I wanted to use as an optical element. I then built the microscope using 3D printed building blocks and implemented a remote control. With this microscope, I managed to capture a fly with 24× magnification.

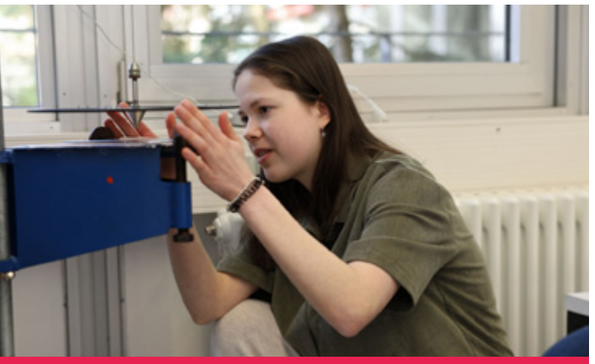
The results had to be presented on the day of the competition. The time limit, as well as the critical questions from the jury and our competitors, were an exciting challenge. The social aspect was not neglected either. Thanks to the community activities, I had a fantastic time — and not just during the day, but sometimes well into the night.

Looking back, I was able to gain a lot of knowledge and experience during the national round of the competition. This also includes the realization that there is always room for improvement. For example, I realized that I should spend more time explaining the basics of my experiments and setting priorities more clearly. I would like to take this opportunity to express my sincere thanks and praise to the planning and administration of the competition in Bad Honnef, as well as of course to the regional organizers. Thank you very much for this adventure!



Result of the water drop microscope: A common fly 24-timesmagnified. Photo: PhotonLab

Mihailo Macesic



Laura Schroeder conducts a practical experiment on torsion at the selection workshop at Ulm University.
Photo: PhotonLab

“As I had made it to the selection workshop for the German national team at the national competition in Bad Honnef, which takes place every year in Ulm, I was allowed to work on another of the 17 problems in the three weeks leading up to the workshop. I had chosen problem #1 ‘Invent Yourself’, which asked me to develop a method to find out the number of objects in a box just by shaking the box. After some trial and error, I found a way to convert audio recordings into spectrograms and deduce the number of objects in the box from the color strokes. I don’t even want to know how many hours I spent making audio recordings.

The workshop in Ulm started at the end of March and afterwards all participants presented their results. On Saturday morning we were busy with the theory circle, which consisted of four different stations. Contrary to my expectations, I had a lot of fun because, despite my rather rudimentary theoretical knowledge as a tenth grader, I was able to solve many tasks. For example, we had to revise presentations from previous years and answer various questions, including questions about everyday phenomena using our understanding of physics on a poster.

On Sunday, we climbed the Ulm Minster. Of course, the ‘photo shoot’ was not to be missed. Afterwards, the national teams for the Austrian Young Physicist Tournament (AYPT) and the International Young Physicist Tournament (IYPT) were announced.

I actually made it onto the national team for the AYPT and was allowed to travel to Leoben. That’s a small town in Austria. The team consisted of a twelfth grader from Berlin, a tenth grader from Lörrach and me.

Because we did very well in the match round, we didn’t have to relax or cheer, but rather prepare for the final with Poland and Georgia in less than an hour. The final itself was all the more fun! We were able to give our best again during the presentation as well as during the opposition and the review, and the successful pitches from all the participating teams made the final all the more exciting. In fact, my team and I made it to second place behind Poland and are therefore Vice European Champions of the AYPT 2024.

Looking back, I can say that my participation in this competition has helped me enormously. Whether it was my knowledge of physics, my rhetorical skills as well as scientific work, I was able to improve all of these thanks to this competition.

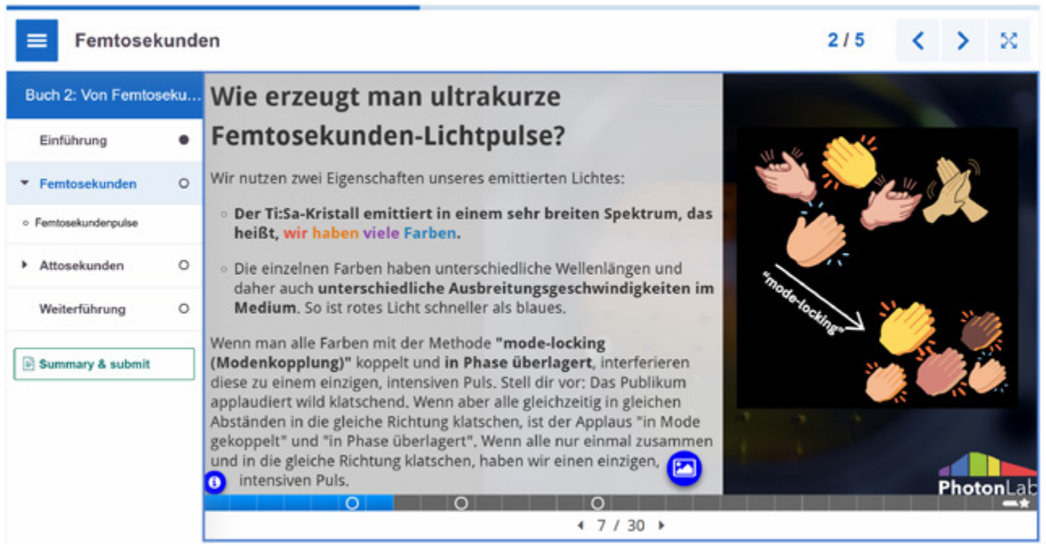
Even though it obviously involved a lot of work and time, it was definitely worth it, as I met a lot of great people, was able to travel several times and have countless unforgettable experiences.”

Laura Schroeder

interactive attosecond physics

october 25, 2024 // Sofie Silbermann

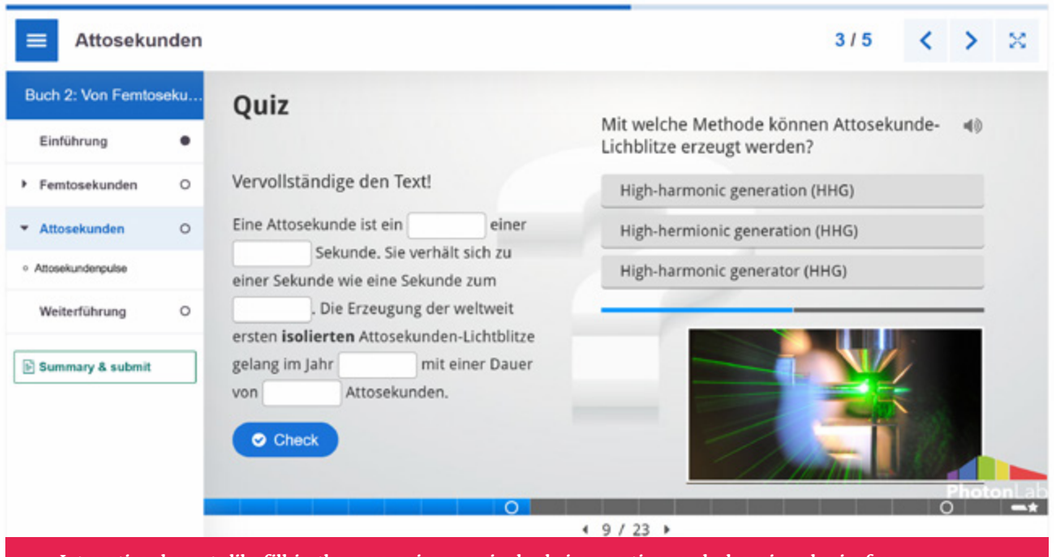
What do you say when someone asks you about your job at a party? Do you say you are a physicist and work with ultrashort times? Do you say you work in a laser laboratory and do something with quanta? Or do you still seriously try to explain to people without a physics background what exactly you do at MPQ and perhaps bore them with it? Those days are over! At the PhotonLab, Umai Chibbaro and Sofie Silbermann have developed an interactive book that explains the contents of the Nobel Prize 2023 at student level. Sofie Silbermann presents the book here.



Mode-locking explained with a literal hands-on introduction.

First of all, we explain the dimensions of attosecond timescales by comparing them with the lengths that light needs to cover distances. For example, light crosses a water molecule in one attosecond and the distance from the earth to the moon in one second. We explain ‘mode-locking’ — a prerequisite for ultrashort light pulses — with synchronized clapping hands, attoseconds with a guitar: all this is ultrafast

physics and in our book literally in a nutshell. If you want to know exactly what we mean by this and would like to familiarize yourself with the subject matter, you can read the interactive book in our flipped classroom. In the PhotonLab, students from the 9th grade onwards also do this, working through the content independently at home. They then go into more detail at school or in the student lab.



Interactive elements like fill-in-the-gaps-quizzes or single-choice-questions make learning physics fun.

The interactive book is developed in the H5P software, which can be easily embedded in the Moodle learning platform and is therefore ideal for use in the classroom.

In three interactive books, which are summarized under the title 'Ultrafast Physics', students learn the basics of understanding (Book 1), the physical generation of femto- and attoseconds with chirped mirrors, the femtosecond laser with a Ti:Sa crystal and mode-locking (Book 2) and possible applications with a focus on medical physics (Book 3). In small bites, the individual chapters of the books, the students can get to know digestible portions of information about ultrafast physics and are provided with illustrative analogies. At the end of each learning unit, there are short quizzes to test their understanding. Teachers can see directly on Moodle how many times a quiz has been completed so that it is 100 percent correct.

The innovation of this book is that it brings together many sources in a way that has never been done before. In addition to popular science lectures and articles such as the Zeit interview by Prof. Ferenc Krausz, the Jugend-forscht lecture by Dr. Alexander Weigl or the introductory lecture by Dr. Silke Stähler-Schöpf, more scientific materials are also embedded, such as the excursus of the Nobel Prize lecture by Prof.



Sofie Silbermann, working student at the PhotonLab since 2020.
Photo: Thorsten Naeser

Anne L'Huillier, who explains overtones with the help of vibrations in music, or the famous paper 'Attosecond metrology', which appeared in the magazine 'Nature' in November 2001 shortly after the successful generation of isolated attosecond pulses.

The various approaches to explaining the facts are particularly valuable from a didactic point of view in order to reach as many people as possible — young and old. With videos, text elements, sketches, pop-up buttons, GIFs and memes or photos, the content is presented in a didactic way so that there is something for every type of learner. This book is for everyone.

With the Ultrafast Physics Book, we offer an insight into the relevance of the Nobel Prize 2023, the opportunities it presents and how they are useful for us in everyday life. We want to pass on the spirit of research that we feel here every day to the public — and now you can easily explain at a party what you actually do in the ATTO-WORLD-team.

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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 developing in the minds of researchers and engineers to make light the tool of the 21st century. On the following pages we publish some samples.

in the microcosm

october 21, 2024 // Thorsten Naeser

Spectacular view into the brain: Dr. Bruno Cisterna and Dr. Eric Vitroli from Augusta University (Georgia, USA) have been awarded this year's Nikon Small Word Photo Prize for their image of differentiated mouse brain tumor cells. The photo simultaneously shows the actin cytoskeleton, the microtubules and the nuclei of the thinking organ.

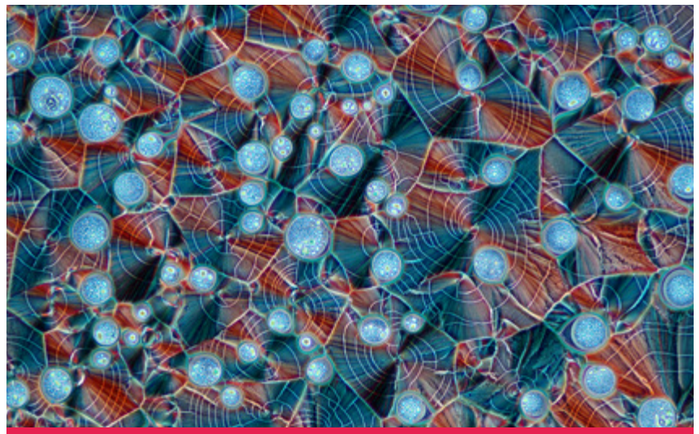
Magnified 100 times, the image shows how disturbances in the cytoskeleton of the cell can lead to diseases such as Alzheimer's and ALS. Research by Bruno Cisterna's team has shown that profilin 1 (PFN1), a protein that is crucial for building cell structure, plays a key role in maintaining the microtubule highways that are essential for cell transport. When PFN1 or related processes are disrupted, these pathways can no longer function properly. This leads to cellular damage, as seen in neurodegenerative diseases.

Patience was required when creating the image. "We spent about three months perfecting the staining process to achieve clear visibility of the cells," explains Bruno Cisterna. "After giving the cells five days to differentiate, we had to find the right field of view in which the differentiated and non-differentiated cells interacted. This required about three hours of precise observation under the microscope until we caught the right moment."

All images can be admired at www.nikonsmallworld.com (see QR-code below)



Slime mold on a rotten twig with water droplets, image stacking, 4.5× magnification. Image: Ferenc Halmos



Recrystallized mixture of hydroquinone and myoinositol, polarized light, 10× magnification. Image: Marek Mis



Stonewort algae (Chara virgata) reproductive organs – oogonia (female organs) and antheridia (male organs), darkfield microscopy, 4× magnification. Image: Dr. Bednar Frantisek



Saltwater shrimp, darkfield microscopy, image stacking, polarized light, 4× magnification.
Image: Dr. Christopher Alger

www.nikonsmallworld.com

AI amidst technological revolution

october 15, 2024 // Vasileios Papalampropoulos

It is very hard to pinpoint exactly the time AI swerved into our lives completely changing the possibilities available by the existing technology. AI is by no means something recent as most of the people believe. Its theoretical aspects can be traced back to the earliest days of computation in the 40s and 50s with the most famous concept from that era being the well-known Turing test introduced in his 1950 paper "Computing Machinery and Intelligence". This paper opens with a crucial question 'Can machines think?' with Turing stating that if a human evaluator is unable to distinguish the answers between a machine and a human through a text-based interface, then that machine is said to has passed the Turing test, suggesting that it can mimic human-like thinking. In this article Vasileios Papalampropoulos gives an overview over how Artificial Intelligence has developed over the decades and what we might can expect from this new era of data science.

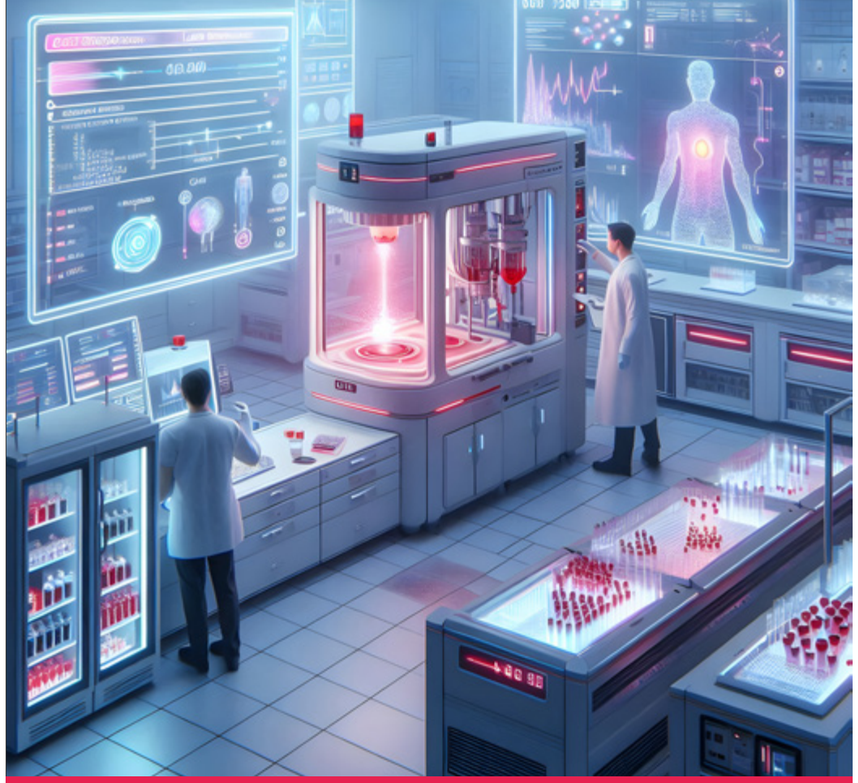
We have now reached the state of having advanced conversational AI models able to engage in a wide range of conversations with the ability to answer questions providing complicated explanations and assisting in multiple tasks ranging from solving math equations to writing programming code. AI today is used by almost any person with internet access to assist with simple tasks with chat-GPT being the most famous one.

But why now? Which parameters lined up perfectly to make AI possible to exist. The main limitation we had in the past was the computational performance of our electronics. To put it into perspective, from 1971 which marks the day of the first commercially produced microprocessor to today, processing power has increased roughly 100 million times for processors and 20 billion times if we compare it with GPU (Graphics Processing Units) widely recognized and commercialized in the late 90s.

Science is mostly driven by investments through R&D for companies that create new technologies and thus by analysing the stock prices someone can have a decent insight which areas are developing or tend to develop in the following years. In the previous paragraph we mention GPUs that have immense processing capabilities using parallel computations making them the most efficient when it comes to neural networks training. Mainly for that reason, Nvidia has invested heavily in their CUDA architecture and advanced parallel processing capabilities while also maintaining 75% of the market share of GPU manufacturing. Like this, they became the most evaluated company worldwide in a matter of months with their stock rapidly rising.

AI has heavily infiltrated every aspect of science being used for research purposes. The Nobel prizes for Physics and Chemistry both were awarded this year to individuals for their contributions to artificial neural networks for the former and protein structure prediction and computational protein design for the latter. This stands as a testament to how highly Artificial Intelligence is viewed by the scientific community. Which begs the question for the next paragraph of this article "How can AI being implemented in the future and what types of future technologies may arise from that?".

We can start by presenting the AI possibilities in medicine and disease diagnostics. In every case it is always optimal to treat disease before it has progressed to a more advanced stage and that cannot be further from the truth when it comes to cancer. The survival rate of every cancer type significantly decreases as the disease progresses to



AI can be used to found patterns between the blood markers to identify the disease much earlier and that can also be the case for other diseases like diabetes, neurological disorders and cardiovascular diseases.
Image: Vasileios Papalampropoulos with "Bing Image Creator"

advanced stages making the need of a blood probing very promising for battling this disease that kills millions every year while also burdening the national health system of every country. AI can be used to find patterns between the blood markers to identify the disease much earlier and that can also be the case for other diseases like diabetes, neurological disorders and cardiovascular diseases.

In the context of cardiovascular diseases, AI can be implemented to predict a heart attack before it even happens by using data collected by wearable technology. By 2024 roughly 30% to 40% of Americans are using smartwatches or fitness trackers containing health monitoring



AI can be used for advance simulations in material science helping scientists create exotic materials with extreme mechanical properties. Those materials can be used in various applications like aerospace engineering.
Image: Vasileios Papalampropoulos with "Chat GPT"

photonworld.de

features able to measure the user's heartbeat throughout the day. By using the data collected from smartwatches belonging to patients that have suffered a heart attack we might be able to create a model able to recognize a pattern to those individuals' heartrates. By doing so, we can use the same model to identify and subsequently warn a new user that a heart attack might be imminent in the following hours or even days before this happens incentivising the user to seek medical attention.

Aside from the breakthroughs in the medical field, AI can be used for advance simulations in material science helping scientists create exotic materials with extreme mechanical properties. Those materials can be used in various applications like aerospace engineering as well as for civil engineering. The days where a high magnitude earthquake could level an entire city might be a thing of the past. In the near future more durable materials that are also economically viable may be used in a large scale. Solar panels able to harvest a large percentage of the solar radiation can help the transition to green energy by being implemented in house roofs to relief the burden in the network during the high demand present in the middle of the day. Renewable energy is completely dependant to physical phenomena of earth's weather, especially when it comes to solar and wind power, and thus can be extremely unreliable for extensive use. A way to counter this is to connect multiple sources of renewable energy like solar, wind and hydroelectricity. Using sophisticated microcontroller monitoring that captures the solar activity and the wind we can use an AI that will control the function of the hydroelectric dam. Hydroelectric power can quickly be ramped up or down to meet demand when solar or wind output fluctuates, thus having a reliable power network by releasing water from the reservoir when the renewable output is low, and storing water when the output is high.

Self-driving cars have already shown us very promising results with the level of automation reaching high levels even today. When the models and the technology reach safety levels that might surpass the human drivers and that is something we will see throughout the 2 next decades, we might start to see a slow transitioning to self-driving cars caused by basic economical motives combined with some functionality benefits. Self-driving cars will become cheaper for sure and will have the ability to be driven more fuel efficiently, if they use fuel to begin with, thus making them more attractive to the consumer based on logistics. Another advantage is the ability for minors to use the vehicle without having the need for a driver´s license. This would make the responsibility to "take the kids to school" a thing of the past. The ability for the vehicle to be used for a night out without the concern of exceeding the amount of alcohol can also be considered a plus for many.

In the far future, when space travel might be more accessible, we can benefit from autonomous navigation making real time decisions during flight. Space missions can generate vast amounts of data requi-



During this century we can use artificial intelligence for an upcoming mission to mars to analyse the data collected by the crew sent there or alternatively to control robots able to navigate challenging terrains, conduct experiments, and make decisions without direct human intervention. Image: Vasileios Papalampropoulos with "Chat GPT"

ring the use of AI to help scientists identify patterns, anomalies, and potential discoveries in fields like astrophysics and planetary science.

In a farfetched scenario we manage to achieve interstellar travel monitoring spacecraft systems to predict potential failures before they occur, while also managing systems over long durations and distances without constant human oversight. All this can implemented with AI. More realistically, during this century we can use artificial intelligence for an upcoming mission to mars to analyse the data col-lected by the crew sent there or alternatively to control robots able to navigate challenging terrains, conduct experiments, and make decisions without direct human intervention. AI interfaces inside astronaut suits can actively monitor their health, managing life support systems, and providing decision support in high-stress situations.

What about the future of computing using AI tools? Already existing technologies like classical computers can become increasingly faster and better with the introduction of composite materials that are better at handling temperatures and other scaling issues that silicon faces in modern transistors. We have already mostly pushed the semiconductor technology leaving behind a small room for improvement, we are not going to see 100-million-fold increase in computation power as we experienced in the last decades. So, if semiconductor technology isn't going to be improved to the same extent we need to investigate



AI can assist in designing and understanding quantum algorithms and systems by modelling quantum phenomena while also expedite the discovery of new materials for quantum computing, such as better qubit designs.
Image: Vasileios Papalampropoulos with "Bing Image Creator"

new computation technologies like quantum computing. Quantum computing star-ted as a concept around the early 70s roughly the same time microprocessor technology started. It was further developed in the 1980s when quan-tum computing started to catch the attention of famous physicists like Richard Feynman who gave an MIT talk discussing the inability of classical computers to simulate the evolution of a quantum system proposing a basic model for a quantum computer. By then efforts had been made to improve quantum error correction, developing more stable qubit technologies, and exploring applications in cryptography, material science, and complex problem solving. In many modern-day algorithms that require polynomial time such as Shor's Algorithm, a sufficiently powerful quantum computer can solve it in a matter of hours or days with a classical requiring millions of years. AI can assist in designing and understanding quantum algorithms and systems by modelling quantum phenomena while also expediting the discovery of new materials for quantum computing, such as better qubit designs or error correction methods.

One thing is sure, AI will completely change the way scientific progress is made completely revolutionizing research. No one knows what awaits us in the future and many of the technologies that were discussed here fall between implementation and speculation.

Will it one day be possible to beam people from one place to another? Sounds difficult. It cannot be ruled out that AI will play a decisive role in this.
Image: Vasileios Papalampropoulos with "Chat GPT"





Image: Kristin Erdmann

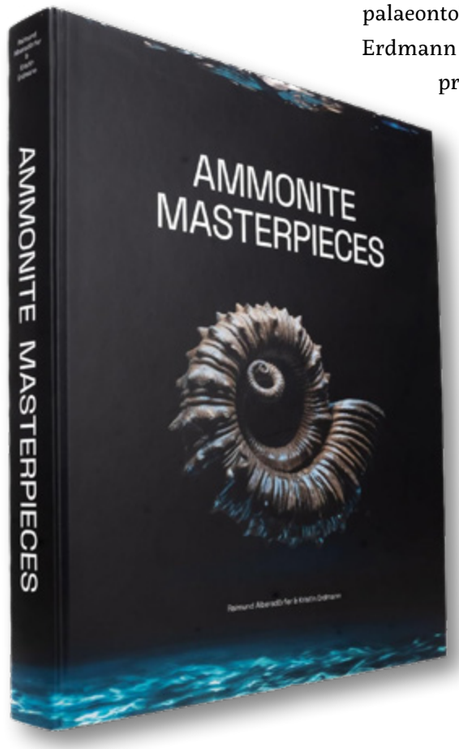
kings of the primordial oceans

december 2, 2024 // Thorsten Naeser

They were the undisputed rulers of the primordial oceans. Ammonites populated the earth for over 350 million years. However, 65 million years ago, they died out together with the dinosaurs. However, their shells have survived to this day. And there are an incredible number and variety of them. Sometimes perfectly coiled according to the rules of the golden section, sometimes elongated like a tube or in spectacularly iridescent specimens made of mother-of-pearl. With the evolution of ammonites, nature has impressively demonstrated its wealth of ideas and engineering skills.



Photographer Kristin Erdmann portrayed the ammonites in large-format pictures in her studio. Image: Private



A particularly attractive specimen from Madagascar prompted palaeontologist Raimund Albersdörfer and photographer Kristin Erdmann to dedicate a book and an exhibition to these fascinating prehistoric animals. The two went on a worldwide search for the most beautiful finds. “We received a huge amount of support that we never expected,” they write in the foreword to their recently published illustrated book ‘Ammonite Masterpieces’. For this ambitious project, the most renowned collectors donated their best finds to the pair. The most experienced taxidermists worked late into the night to bring some pieces to their full beauty before they were to be photographed and exhibited.

The result is an opulent book that illuminates all facets of ammonites. In outstanding photographs, the prehistoric animals unfold their second life. In addition, Raimund Albersdörfer and Kristin Erdmann explain the biology of the animals. They introduce the collectors and explain how the fossils are prepared in order to present their full attractiveness. The two have succeeded in creating a comprehensive compendium that sets new photographic standards and arouses curiosity about these extinct rulers of the primordial oceans.

Ammonite Masterpieces
Raimund Albersdörfer & Kristin Erdmann
Albersdörfer Fossilien GmbH (2024)
86,00 €
ISBN-13: 978-3000781766 (German)

Exhibition:

The ‘Dinosaur Museum Altmühltal’ is showing more than 120 of the best ammonites from all over the world in the special exhibition “Ammonite Masterpieces”. Many of the fascinating prehistoric creatures are on display in Germany for the first time. The octopuses dominated the oceans for more than 350 million years before they became extinct at the same time as the dinosaurs.

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dinosauriermuseum.de

photonworld.de



“Our goal is to develop optogenetic therapies that would allow patients to see in a normal room environment without additional aids.”

[Prof. Dr. Botond Roska]

october 18, 2024 // Thorsten Naeser

Prof. Dr. Botond Roska has been awarded the 2024 Wolf Prize for Medicine together with José-Alain Sahel for groundbreaking work on restoring sight in blind patients using optogenetic therapy. The Hungarian-Swiss neuroscientist from the Institute of Molecular and Clinical Ophthalmology (IOB) at the University of Basel is considered a leader in the field of restoring lost vision. In this interview with Thorsten Naeser, he explains his work and gives an outlook on the possibilities that optogenetic therapy approaches could offer in the future.

How did you come to specialize in ophthalmology?

My journey into ophthalmology began after I completed my medical studies. At a dinner, I had a chance encounter with someone who studied the retina. Our long conversation ignited my excitement about this part of the brain that could be understood completely in isolation. This inspired me to pursue a PhD after my medical studies, which I completed at Berkeley under Professor Frank Werblin.

After finishing my PhD, I came across a publication demonstrating that light sensors from algae could be expressed in cells, enabling them to react to light. I saw this as an opportunity to combine my medical background with my research interests to restore vision.

To further my knowledge, I went to Harvard to work with Connie Cepko, learning about molecular genetics and virology. Subsequently, I returned to Europe, settling in Switzerland to start my own research group. There, I focused on understanding the retina and the visual system in general, as well as developing new therapies for restoring vision. It was during this time that I met José Sahel, and our paths have been closely intertwined ever since, collaborating on various projects.

When you look at our eyes, how would you describe them from an evolutionary and technical perspective?

When I look at the eye, my focus is always drawn to the retina — the truly sophisticated and crucial part of the eye. The retina is essentially a part of our brain that, during development, bulges out to become a brain component that observes the world.

This brain part functions as a highly sophisticated computer with three main components. First, there's a layer of photoreceptors that capture the image. On the other end, there's a layer that sends the final processed information to the brain. Between these two layers lies a complex computing infrastructure. Unlike digital computers, the retina has many different types of processors interconnected. Their job is to extract various types of information from the visual world, simultaneously broadcasting this information to the brain.

The structure of the retina is highly conserved across all vertebrates, from fish to humans. However, there are important differences, particularly relevant to understanding diseases. That’s why it’s crucial for us to understand how the human retina works and to develop new disease models in the context of the human retina.

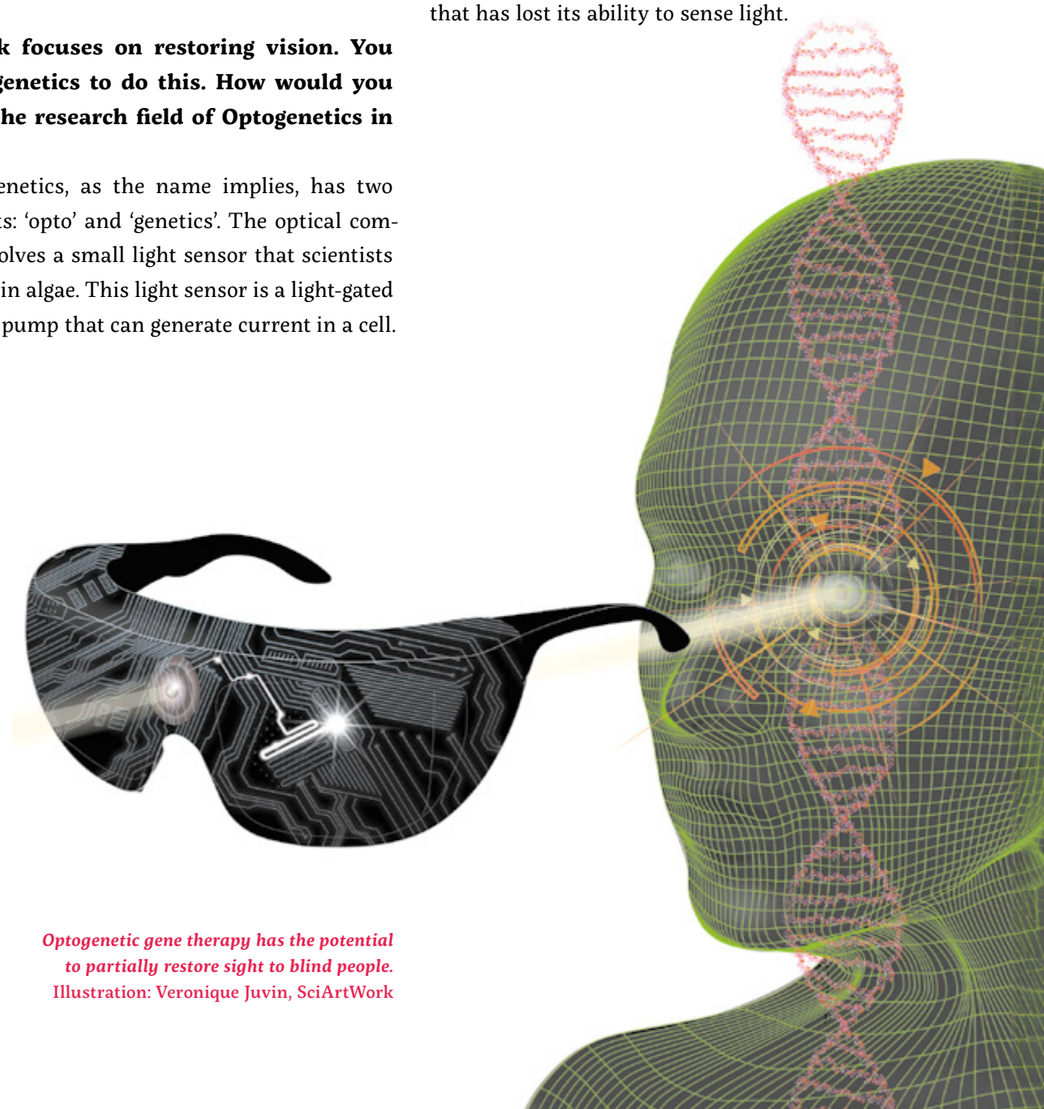
Your work focuses on restoring vision. You use Optogenetics to do this. How would you describe the research field of Optogenetics in general?

Optogenetics, as the name implies, has two components: ‘opto’ and ‘genetics’. The optical component involves a small light sensor that scientists discovered in algae. This light sensor is a light-gated channel or pump that can generate current in a cell. The key point is its simplicity — a single gene encoding a single protein is able to confer light sensitivity to a cell.

The genetic component involves the delivery method. We can package this optoGene, the sensor, into a viral vector, and target this viral vector to specific cell types in the brain or retina, thereby making the targeted cells light-sensitive.

Why is Optogenetics in particular so promising for the treatment of retinal diseases?

The key promise of optogenetic therapy lies in its ability to make a blind retina light-sensitive again. By delivering a light sensor to particular cell types in the retina, we can restore some function to a retina that has lost its ability to sense light.



Optogenetic gene therapy has the potential to partially restore sight to blind people.
Illustration: Veronique Juvin, SciArtWork



Photo: Group Botond Roska

It's important to note that this approach isn't suitable for all retinal diseases. However, it's particularly promising for those blinding diseases caused by photoreceptor dysfunction. In these cases, optogenetics offers a way to bypass the damaged photoreceptors and directly stimulate the remaining retinal cells, restoring some level of visual function.

Your team has used algae-derived genes to create light-sensitive cells to treat degenerative retinal diseases. That sounds very fancy. How can we imagine such a therapeutic approach?

Indeed, while the molecular technology behind it is sophisticated, the therapeutic approach itself is surprisingly straightforward. We package the gene encoding the light-sensitive protein (derived from algae) into a viral vector. This results in a solution that can be directly administered to the eye.

The administration is performed by an ophthalmic surgeon. Depending on which cell type we're targeting, the solution is injected either intravitreally (into the vitreous humor of the eye) or subretinally (under the retina). This simple injection delivers the optogenetic tool to the target cells, enabling them to respond to light and restore some visual function

.In your opinion, what opportunities or perhaps risks does Optogenetics offer for the future of ophthalmology?

The key opportunity that optogenetics offers is its potential for vision restoration that doesn't depend on the particular gene mutation causing the disease. There are approximately 280 different genes that can cause inherited retinal degeneration leading to blindness. Theoretically, all of these could be treated by the same optogenetic approach. This universality is a significant advantage.

However, there are challenges to consider. The main risk or limitation is that we might not be able to achieve sufficient light sensitivity with our current optogenetic tools. As a result, patients receiving this therapy might need additional aids, such as special goggles that amplify light, to function in normal room lighting conditions.

Looking ahead, our future work is focused on enhancing photosensitivity. Our goal is to develop optogenetic therapies that would allow patients to see in a normal room environment without additional aids. This would significantly improve the quality of life for individuals with severe vision loss due to retinal degeneration.

contact:

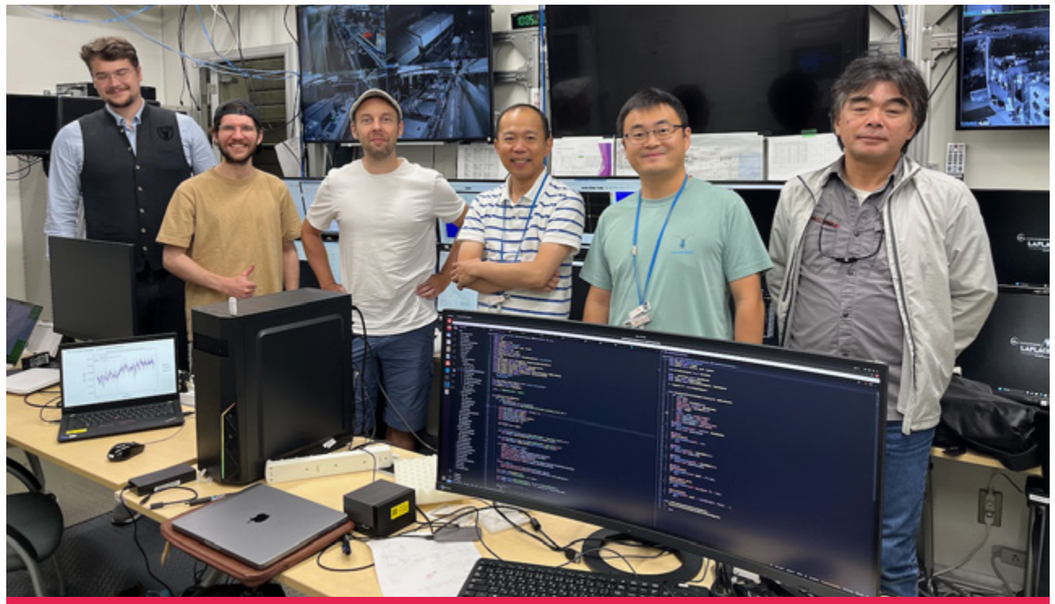
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At the Centre for Advanced Laser Applications (CALA), physicists, physicians and biologists are exploring the practical potential of a unique array of state-of-the-art laser technologies. Their principal goal is to develop sensitive and cost-efficient laser-based methods for detection and therapy of cancer and other types of chronic disease, as early diagnosis is the key to successful treatment of these conditions.

making every measurement count: how AI helps us learn from limited data

november 13, 2024 // Dr. Andreas Döpp

How do you optimize a complex system when you can only test dozens up to a few hundred different settings, each measurement is noisy, and the system itself may drift over time? This is the question posed by the team led by Dr. Andreas Döpp, research group leader at the Centre for Advanced Laser Applications (CALA). Experiments at ATLAS3000, one of the most powerful lasers at European universities, mean that the laser physicists can only obtain limited data directly due to the technical possibilities. With AI, the physicists are able to optimize the experiments and better interpret the results obtained. Andreas Döpp reports here on this innovative approach.



International Collaboration: DOLPHIN-team members conduct Bayesian control experiments with local researchers at Japan's SPRING-8 LAPLACIAN facility. Photos: DOLPHIN-group



Knowledge Transfer: Graduate researchers Christoph Eberle and Faran Irshad mentor undergraduate student Joël Marth on Bayesian Optimization techniques.

When people think of artificial intelligence today, they often imagine systems trained on massive amounts of data — from language models processing billions of text documents to image recognition systems analyzing millions of photos. But while data is abundant for everyday phenomena, scientific experiments often probe rare events or extreme conditions that can't be measured easily or frequently. At the Centre for Advanced Laser Applications, the team around Dr. Andreas Döpp works with one of the most powerful laser systems in Europe, capable of generating ultra-intense light pulses that can accelerate particles close to the speed of light. Despite the system's impressive capabilities, measurements are inherently limited the scientists can only fire the laser once per second, and some experiments require specially fabricated targets that can only be used once.

This creates an interesting challenge: How do you optimize a complex system when you can only test dozens up to a few hundred different settings, each measurement is noisy, and the system itself may drift over time? Traditional machine learning approaches that require thousands or millions of examples simply won't work here. Instead, we need methods that can learn and make decisions efficiently from limited, noisy data.

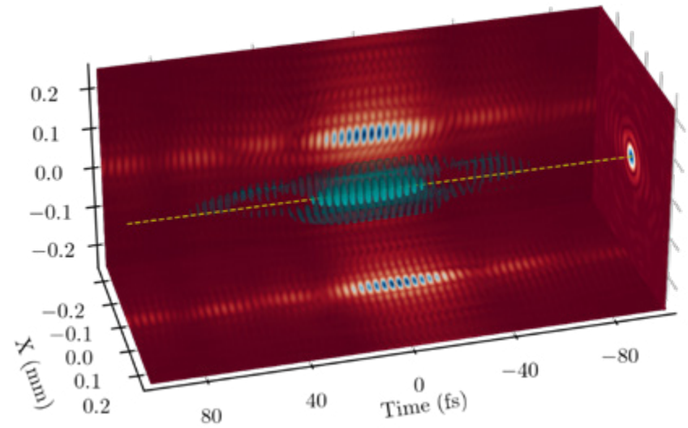
The key insight comes from a mathematical framework developed by Thomas Bayes in the 18th century. Bayes showed how to systematically update our beliefs as new evidence becomes available. Unlike traditional statistics that requires many measurements to make confident statements, Bayesian methods explicitly model our uncertainty. They combine prior knowledge with new measurements, gradually refining our understanding of a system.

This approach mirrors the scientific process: we start with what we know (or think we know), make measurements to test our understanding, and update our beliefs based on the results. The mathematical framework lets us do this rigorously and systematically. For instance, when characterizing our laser pulses, each new measurement refines our knowledge of the pulse shape while maintaining a precise estimate of our uncertainty. Similarly, when tuning our particle accelerator, the system tracks not just what parameters might work best, but how confident it is in its predictions.

What makes this particularly powerful is that we can use our uncertainty estimates to make better decisions about what to measure next. Rather than testing random combinations or following simple rules, we can systematically choose measurements that will teach us the most about our system. This turns experimental optimization from a process of trial and error into one of methodical discovery.

In recent experiments, we demonstrated how this approach could tune a laser-driven particle accelerator by adjusting eight different parameters simultaneously — a task that would be practically impossible for human operators. More importantly, it achieved this using only about a hundred different settings, each tested with just a few shots to account for natural fluctuations.

As we push the boundaries of science and technology, this ability to learn efficiently from limited data becomes increasingly crucial. It's not just about processing more data — it's about asking the right questions and making every measurement count.



Breakthrough Insights: 3D rendering of a single laser pulse captured using novel diagnostic technology developed by the team. Figure: DOLPHIN-group

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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.

happy birthday, UFI!

15 years of Ultrafast Innovations GmbH

november 19, 2024 // Dr. Veit Ziegelmaier

Cast off! In Gmund am Tegernsee, a chartered cruise ship departed from the shore in glorious sunshine on July 11, 2024. On board were the management and staff of Ultrafast Innovations (UFI), who had every reason to celebrate: the company's 15th anniversary. With a round trip on Lake Tegernsee, a mini golf tournament and a rest stop at the popular 'Bräustüberl'. Starting its activities on July 1, 2009, as a spin-off of Ludwig-Maximilians-Universität München (LMU Munich) and the Max Planck Institute of Quantum Optics (MPQ), UFI was co-founded by Prof. Ferenc Krausz, a leading expert in attosecond physics and Nobel Laureate in Physics 2023. Since then UFI has successfully transferred cutting-edge scientific research into industrial applications, offering advanced optics and optical devices specifically designed for ultrashort (laser pulse) physics.

Originally focused on the production of multilayer optics, for which Dr. Vladimir Pervak is in charge, UFI has steadily expanded its portfolio to include a wide range of optical technologies. Today, customized solutions play a central role in the company's offerings. The company specializes in custom-designed optical components such as beam splitters, pulse compressors, optical delay lines, and multiphoton detectors, tailored for high-performance laser systems. These devices are essential for advancing research in areas like ultrafast spectroscopy, precision measurement, and time-resolved imaging. UFI also provides solutions for extreme environments, where the physical conditions — such as high intensities or ultrafast time scales — require specialized optical materials and designs.



In July 2024, UFI celebrated its 15th anniversary with a team outing to Tegernsee. The event featured a boat trip with a traditional Bavarian breakfast, a mini-golf tournament, and a visit to the 'Tegernseer Bräustüberl'. Photo: UFI

UltraFast Innovations GmbH

The company collaborates closely with research institutions, laboratories, and industrial clients to develop innovative products tailored to specific needs. These offerings encompass custom-designed optics specifically crafted for ultrafast laser pulses, specialized optical devices that seamlessly integrate with existing systems, and bespoke solutions designed to perform in challenging environments. This includes applications in cutting-edge fields such as attosecond physics and high-energy laser systems.



Excerpt from a UFI LinkedIn post explaining the names of the devices: Named after the Madeira river in South America, the carrier-envelope-phase meter measures the electric-field shape of ultra-short light pulses, which resembles the meandering turns of the river as it winds its path through the landscape. Image: Thorsten Naeser & Dennis Luck

A distinguishing feature of UFI's optical devices is their unique and creative names, inspired by natural landmarks and regions around the world. Products such as EVEREST, NEPAL, TUNDRA, MADEIRA, and GOBI symbolize the durability and uniqueness of the devices while adding a creative dimension to their identity.

Since its inception, UFI has experienced continuous growth in both workforce and revenue. The company now employs more than 30 highly skilled professionals and operates from its headquarter in Dieselstr. 5, Garching, which houses two laboratories for device manufacturing. Under the current leadership of Dr. Alexander Guggenmos (CEO) together with Dr. Asger Kreiner (CTO), and Dr. Verónica Oliver (COO), UFI has established itself as an important competitor in the optics industry. The company actively participates in international conferences and trade fairs, with recent showcases in cities such as Barcelona, Cozumel, Denver, Osaka, Paris, San Francisco, Strasbourg, and Vienna.

UFI's strength lies in its ability to combine standardized high-quality products with tailored solutions for diverse applications. This adaptability, coupled with its strong foundation in research and technology, ensures that the company is well-positioned to meet the evolving challenges of the optics industry. By bridging fundamental research and industrial applications, UFI continues to exemplify how scientific expertise drives technological and economic success — a commitment it has upheld for 15 years.

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In 2022, PULSED was incorporated as independent spin-off from the LMU Munich and the Max Planck Society. It makes phase-stable, ultrashort-pulse infrared lasers commercially available. These laser sources are highly attractive for a wide range of scientific applications, such as ultrafast nanoscopy, lightwave electronics, and more. PULSED's long-term vision is to provide the technology for electric-field molecular fingerprinting for medical applications, which is expected to have tremendous impact as a technique for population-wide health monitoring and disease detection.

PULSED

an exciting second year

october 15, 2024 // Dr. Nils-Holger Haag

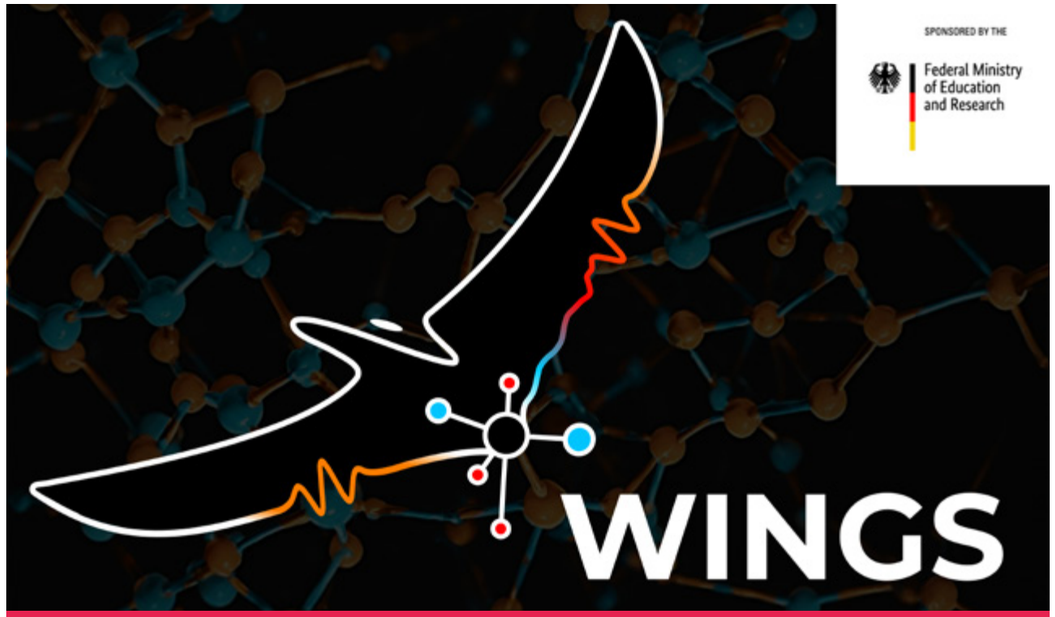
The year 2024 was full of milestones and exciting developments for the young PULSED GmbH. Here, Managing Director Dr. Nils Haag reports on the events of the past year.

In July, we celebrated our second birthday and of course such a young company develops significantly when doubling its age. In the course of 2024 we were able to gain more motivated and talented team members. For the first time, we hired engineers who are not from the ATTOWORLD-family. Laser engineer Lukas Brahmann joined us in February and photonics engineer Shivam Lakum started in June. As expected, the two have settled wonderfully with the ever-growing workforce, which is now in the double digits. And with Renate Sailer, we were even able to win an old acquaintance who is well-known to some long-standing members of ATTOWORLD.



Nathalie and Philipp installing two albatross systems.
Photo: PULSED

With this reinforcement, we have managed to make our vision of a commercial 'albatross' laser come true this year. As a reminder, the 'albatross' system is a unique laser for waveform-stable single-cycle pulse generation, which delivers <10 fs at 2.2 µm and at the repetition rate of a laser oscillator. Its characteristics include ultra-low noise of field amplitude and stabilized CEP, resulting in high waveform fidelity.



In the WINGS-project, PULSED and two university partners will develop a ZnS-based platform for field-resolved infrared and pump-probe-spectroscopy. Image: Dr. Nathalie Lenke (PULSED)

As of today, already five systems have found a new home in scientific laser laboratories. And this is just the beginning, as this number will be doubled in the course of the first half of 2025 — partly even due to international orders.

One of the biggest milestones of this year was undoubtedly the acquisition of public funding from the Federal Ministry of Education and Research (BMBF). As part of the Enabling Start-up: Start-ups in Quantum Technologies and Photonics program, we launched the WINGS joint project together with LMU Munich and the University of Regensburg. The common goal is to develop a platform for field-resolved infrared and pump-probe spectroscopy that can serve as a tool for a variety of different applications. Finally, this will be able to serve as a demonstrator platform for molecular fingerprinting and thus serve medical applications. This project allows us not only to maintain the technological lead of ZnS-technology, but to further expand and take it a step closer to realizing our goal of laser-based health monitoring and early disease detection.

We are very much looking forward to an eventful year 2025.

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enLIGHTment:
the magic of light in Ólafur Elíasson's 'The Weather Project' (2003)

november 26, 2024 // Dr. Veit Ziegelmaier

Ólafur Elíasson, born in Copenhagen in 1967, is one of the most influential contemporary artists, whose works fascinatingly merge science, technology, and art. The Danish-Icelandic artist, who grew up between the urban culture of Denmark and the raw nature of Iceland, deeply integrated these two worlds into his artistic practice. After studying at the Royal Danish Academy of Fine Arts in Copenhagen, he founded his studio in Berlin in 1995. Today, this studio serves as an interdisciplinary platform for collaboration among artists, architects, scientists, and technicians. Light plays a central role in Elíasson's work, which often explores the boundaries between nature and artificiality, science and emotion. His installations, including the internationally acclaimed 'The Weather Project' (2003), challenge viewers' perceptions by presenting light not only as a physical phenomenon but also as a cultural and emotional symbol.

'The Weather Project', presented in 2003 in the monumental Turbine Hall of the Tate Modern in London, is one of Elíasson's most impressive installations. It addresses the relationship between humans and nature and the ways we perceive environmental phenomena — especially weather. Technically precise and aesthetically overwhelming, this work uses light as a medium to blur the boundaries between reality and illusion.



The artist Ólafur Elíasson.
Photo: Runa Maya Mørk Huber/Studio Ólafur Elíasson
© 2017 Ólafur Elíasson

The central element of 'The Weather Project' was a massive semicircular disc reminiscent of a rising sun. This "sun" was illuminated by hundreds of high-pressure sodium (HPS) lamps, which are known for their ability to produce an intense, monochromatic yellow-orange light. The color emitted by these lamps falls at a wavelength of approximately 589 nanometers, corresponding to yellow light. This monochromatic light had a unique effect on perception: it suppressed the ability of the human eye to see other colors, reducing the visible spectrum to shades of yellow and gray. Elíasson harnessed this property to immerse the entire Turbine Hall in an otherworldly, almost dreamlike atmosphere.



Ólafur Elíasson — The Weather Project (2003), monofrequency lights, projection foil, haze machines, mirror foil, aluminium, and scaffolding, 26.7 × 22.3 × 155.4m, Turbine Hall, Tate Modern, London.
Photo: Tate Photography (Andrew Dunkley and Marcus Leith)

Another standout feature of the installation was the enormous mirrored ceiling that spanned the entire length of the hall. This ceiling, composed of highly reflective panels, was installed with precision to create the impression that the space extended infinitely upwards. The semicircular "sun" was completed into a perfect circle through its reflection. This optical illusion heightened the perception of infinity,

symbolically opening the space into another dimension. Visitors not only saw the "sun" but also their own reflections, transforming the installation into a site of introspection and self-awareness.

To enhance the visibility of the light beams and amplify the atmosphere, Elíasson used fog machines to release a mixture of water and oil particles into the air. This artificial mist altered how light was perceived, creating a dense, almost tangible structure. The particles scattered the light, rendering its physical presence visible and giving the environment a uniquely immersive quality.

A particularly fascinating aspect of 'The Weather Project' was the interaction between visitors and the space, shaped decisively by the monochromatic light. Since the sodium lamps reduced the visible spectrum to yellow and gray tones, all individuals in the room appeared in the same hues. This subtle yet profound limitation had a deep social and aesthetic impact: distinctions in skin color, clothing, and accessories became nearly indistinguishable. The reduced color palette created a sense of equality, encouraging viewers to look beyond individual characteristics. Instead, the physical presence and interactions of people in the space came to the forefront.



A particularly fascinating aspect of 'The Weather Project' was the interaction between visitors and the space, shaped decisively by the monochromatic light.
Photo: © User:Bjoss, Wikimedia Commons

Through this visual uniformity, visitors became part of a shared collective ensemble. This effect fostered an awareness of the collective experience of the artwork, providing space to reflect on concepts of individuality and community. Elíasson used light as a tool to temporarily dissolve social structures. In a globalized world where differences are often emphasized, he created a space of unity, inviting viewers to see themselves as equal participants in a shared experience.

'The Weather Project' is a spatial installation that delves deeply into the symbolic and emotional meanings of light and weather. The sun — an archetypal symbol of life, warmth, and energy — is portrayed in a way that oscillates between artificial construction and natural experience. Elíasson explores the significance of weather as a cultural and emotional phenomenon. Weather is not merely a physical condition but also a metaphor for human moods and social dynamics. In 'The Weather Project', the sun, a central symbol of weather, is artificially recreated and brought into an urban, enclosed space. This contrast between interior and exterior, nature and culture, prompts viewers to reflect on how we experience and construct nature. In an era of increasing urgency regarding climate change and environmental degradation, the artificial sun takes on an almost prophetic dimension: it serves as both a reminder of nature's beauty and a warning of its potential destruction.

art & science

'The Weather Project' stands in a long tradition of artists using light as a medium, yet it innovatively expands and transforms this tradition. Elíasson's work can be seen as an evolution of 20th-century light art, influenced by figures such as László Moholy-Nagy, Dan Flavin, and James Turrell. While Moholy-Nagy and Flavin primarily used light as a sculptural and kinetic element, Turrell focused on the perception of light as a spatial and physical phenomenon. Elíasson integrates these approaches, employing light as both a physical medium and a carrier of meaning and emotion. Unlike Turrell, whose works are often introspective and meditative, 'The Weather Project' invites interaction and collective experience.

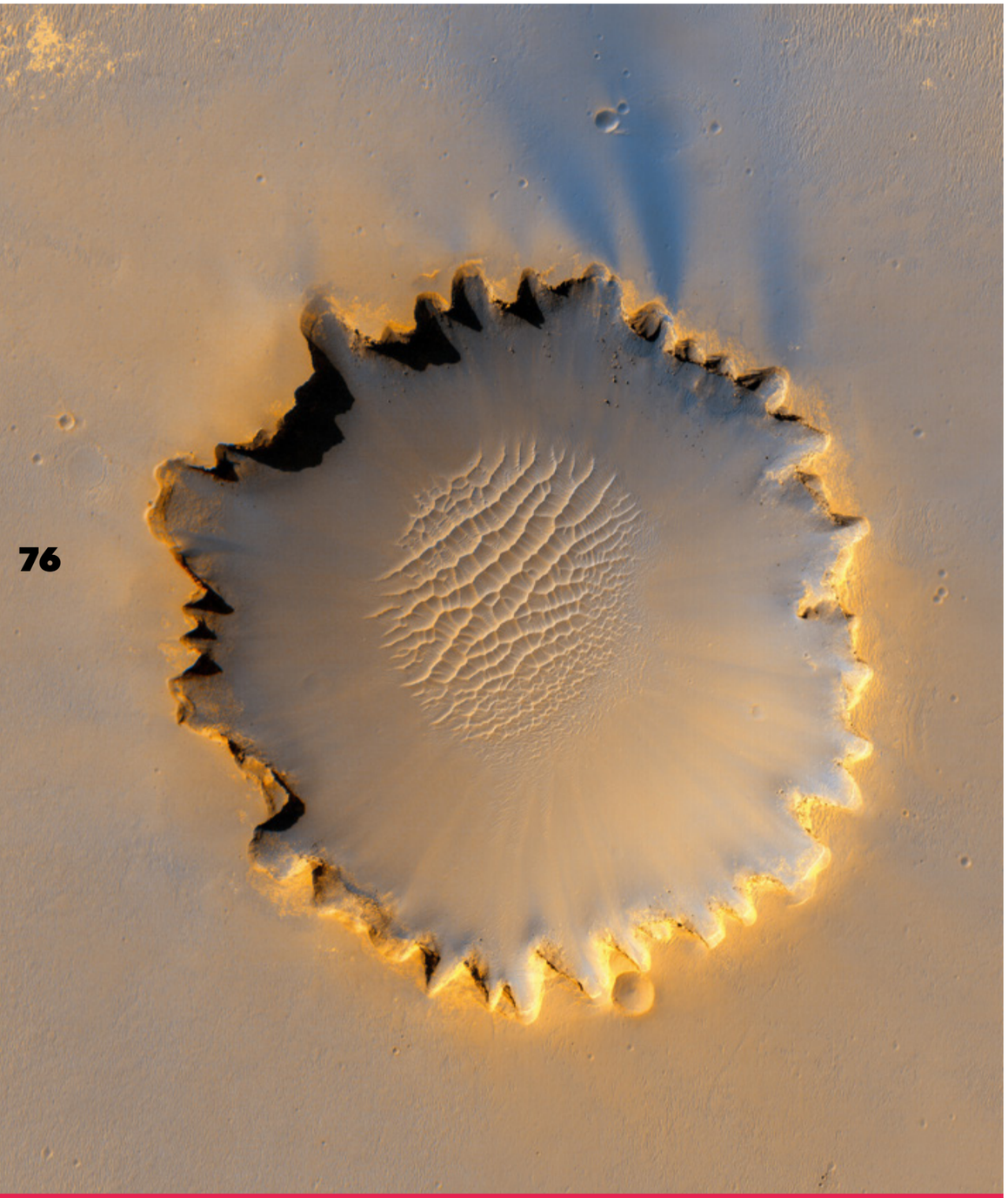
The depiction of weather in art has a long history, dating back to the Romantic landscape painters of the 19th century. Artists like Caspar David Friedrich and J.M.W. Turner used light and atmosphere to convey the power and beauty of nature. Elíasson updates this tradition by not only representing light but also making it physically and spatially experiential. His artificial sun serves as both an homage to Romanticism and a critical engagement with today's relationship between humanity and the environment.

'The Weather Project' is a landmark in contemporary art, seamlessly combining technology, aesthetics, and symbolism. It challenges us to reconsider our perceptions, our relationship with nature, and how we experience community. Elíasson's work reminds us that art is not only a visual experience but also a social and philosophical one — one capable of transforming us as individuals and as a society. This work remains a milestone in light art and an impressive example of how art can transcend the boundaries of science, technology, and emotion.

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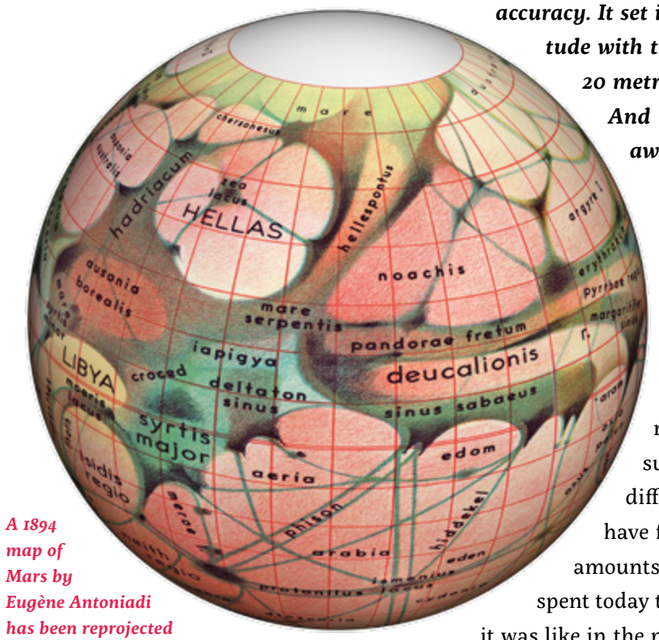
Even before its scientific observations began, Mars Reconnaissance Orbiter used its sharp-eyed HiRISE camera to photograph the Mars Exploration Rovers Spirit and Opportunity on the surface. This photo commemorates Opportunity's arrival at the 800-meter-diameter Victoria crater on the 951st day of Opportunity's mission (the photo was taken 5 days later). The rover is visible as a tiny speck at about 10 o'clock. Opportunity continued exploring Victoria Crater for two further years.
Image: NASA

book presentation

difficult neighbor

november 19, 2024 // Thorsten Naeser

Some astro fans may remember the spectacular landing of 'Perseverance' on Mars on October 18, 2021. A NASA carrier probe transported the rover to the surface of the planet with pinpoint accuracy. It set it down on the surface from a low altitude with the help of ropes and then flew around 20 metres further away from the landing site. And all this from 480 million kilometers away from Earth.



A 1894 map of Mars by Eugène Antoniadi has been reprojected onto a sphere, aiding comparison of the map's features to modern photos of Mars. It shows many straight-line "canali" that do not actually exist, but were rather optical illusions or observational artifacts.
Map: Eugène Antoniadi

Landing the roughly one-ton rover on the Red Planet looked easy, however from a technological point of view it was a brilliant achievement. Space programmes around the world have shown that it is extremely difficult to reach Mars, get into orbit and then land successfully. To put it bluntly: Mars is difficult. About half of all Mars missions have failed. Billions of dollars, as well as vast amounts of brainpower and resources are being spent today to explore what Mars is like — and what it was like in the past. What is it about our nearest neighbour in the solar system that captivates us so much?

All of this is explored in the new book 'Mars – Photographs from the NASA Archives'. In addition to the high-resolution photographs of the surface of Mars, this magnificent, illustrated book published by 'TASCHEN Verlag' also contains fascinating articles on all aspects that have occupied mankind for centuries regarding the Red Planet. The fiery glow of Mars already fascinated astronomers in ancient times. They named the planet after their god of war. And to this day, Mars remains Earth's mysterious neighbour and a source of endless speculation. Was there life there in the distant past or not? That's the big question and a strong incentive for science to shed light on the darkness. In the new compendium, the high-resolution images that NASA has taken of the Red Planet over six decades of rover missions — as the title of the work promises- play significant role. The book is accompanied by essays from former NASA chief scientist James L. Green and JPL engineer Rob Manning. They provide a first-hand insight into the history of Mars research and the challenges that the pioneering missions entailed.

In the final issue in his series for Collier's, Wernher von Braun speculated on the future of manned trips to Mars, in which astronauts, and not just rovers, would travel there in a ten-ship flotilla.



But that's not all. The book goes way back in the history of the exploration of Mars. It sheds light on several historical aspects, such as the early cartography of the planet, long before the first camera was used on site. There is also plenty of offers from a cultural-historical and artistic perspective: The volume presents old posters, drawings and sketches that manifested in the minds of artists, astronomers and engineers over the centuries and were ultimately put down on paper. The artworks highlight Mars from all possible angles and fantastical ideas, such as the painting by South African architect William Timlin dated 1923, which is reminiscent of a sunset where Mars is the bright star. It shows an engineer's sailing ship, built by fairies, sailing to the 'Shining City of Mars'.

With the appealing and largely unknown artificial illustrations, the book has received an enormous boost. With its successful retrospective, it perfectly rounds off our current image of the red planet, which is dominated by high-resolution and technologically refined images.



MARS. PHOTOGRAPHS FROM THE NASA ARCHIVES
Emily Lakdawalla, James L. Green, Margaret Weitekamp, Nikki Giovanni & Rob Manning
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cover image: **Vasileios Papalampropoulos with AI "ChatGPT/Midjourney" & Dennis J.K.H. Luck (Artwork) with AI "Adobe Firefly"**

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

successfully extended

november 22, 2024 // Lena Beggel

The International Max Planck Research School of Advanced Photon Science (IMPRS-APS) had reason to celebrate last summer. The graduate school was extended for another four years. The new round of applicants has already been successfully completed. We warmly welcome our new PhD students to the attoworld team: Wei Liang, Yang Gui, Vincent Weis and Malte Bieringer. We also welcome Prof. Peter Hommelhof as a new group leader in our team.

The IMPRS-APS promotes networking and career opportunities for young scientists: in addition to visits to the institute, we are planning meetings with companies in and around Garching next year to show our doctoral students new job prospects and further strengthen our links with industry.

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