the magazine of attoworld

volume 6 (2025)

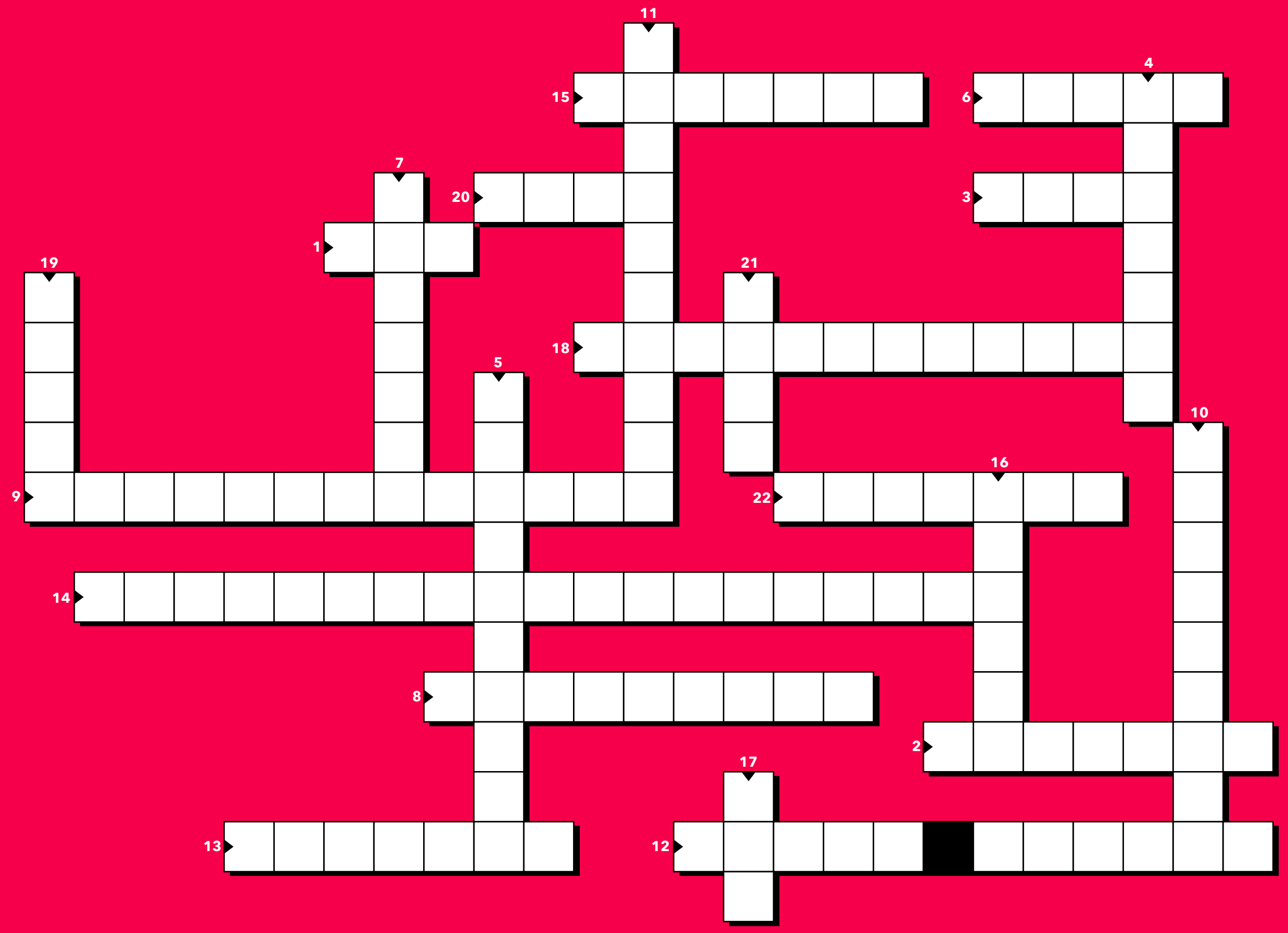
pulse

feature
protecting.health
global initiative

ATTOWORLD
attoworld.de

crossword puzzle

Attention, puzzle lovers! Welcome to pulse magazine. To sweeten your introduction to our publication, we have put together a little crossword puzzle to get you in the mood. You will find the answers on the second-last-page (Imprint).



1. What molecule stores genetic information in organisms?
2. What is the largest ocean on Earth?
3. What is the longest river in the world?
4. What is Earth's highest mountain?
5. What is the coldest continent?
6. What organ primarily detoxifies chemicals?
7. What hormone regulates blood sugar?
8. What technique enables direct time-domain sampling of electron dynamics?
9. What process generates attosecond bursts in high-harmonic generation process?
10. What effect often describes ultrafast strong-field ionization?
11. What optical effect limits the duration of sub-femtosecond optical pulses?
12. What renewable energy source is growing fastest globally?
13. What type of reactor is key to fusion energy research?
14. Which device was used to discover the Higgs boson?
15. What element is essential for modern battery technology?
16. Which virus caused the 2020 global pandemic?
17. What is the main greenhouse gas from fossil fuels?
18. Which branch of physics studies black holes and relativity?
19. What technology enables self-driving cars?
20. Which particle is a candidate for dark matter?
21. Which type of RNA is used in new vaccines?
22. Which chemical element is key for next-generation semiconductors?

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editorial

crossing the borders!

Will we soon be reaching for the stars? It's hard to imagine. After all, the nearest solar system, Alpha Centauri, is 4.37 light-years away. But why not set ambitious goals and consider how to expand the boundaries of humanity?

In this issue of our magazine, you will read about generational spaceships whose concepts are being worked on by architects, social scientists, and engineers worldwide. With these spaceships, we might one day be able to venture into the next solar system over the course of many generations. To do so, we need to leave our comfort zone, develop new ideas, draw on our collective strengths, and, above all, overcome boundaries.

Overcoming boundaries is one of physics' strengths. Of course, there are laws of nature that even physics must adhere to. But the limits of what is physically possible are likely far from being reached. A good example of pushing boundaries was undoubtedly the generation of light flashes lasting only attoseconds in 2001. Now, almost a quarter of a century later, this has provided countless insights into intra-atomic processes. The world of electrons has opened up, and the limits of imaging have shifted to the edge of the atomic nucleus. Who knows when the breakthrough will come and we will be able to see insights from inside an atomic nucleus. We can look forward to it with excitement.

Physics would not be physics if it were a one-way street. And so attosecond technology has surprisingly broken new ground and found its way into medicine. The **ATTOWORLD**-team uses laser technology not only to research the microcosm, but also for infrared spectroscopy of molecules in blood. The goal is to develop a cost-effective diagnostic tool and early detection method for diseases such as cancer and diabetes. Ultimately, only a single drop of blood will be needed for analysis.

What began as a visionary idea about a decade ago has blossomed into a global initiative: With large-scale studies such as Lasers4Life (L4L) or Hungary4Health (H4H), the establishment of the largest Hungarian research project, the Center for Molecular Fingerprinting (CMF) in Budapest, and most recently since Ferenc Krausz's inaugural lecture at the University of Hong Kong (HKU) last November. With its protecting.health-project, the **ATTOWORLD**-team is once again breaking boundaries. This time, geographically. The vision is clear: to establish the first global cooperation for creating the basis for a cost-effective health screening modality for a range of common diseases that will work for all age groups, ethnicities, and countries. Cutting-edge physical technologies will extract deep molecular information from a drop of blood to inform – with the help of artificial intelligence – on a person's health state. You can read about how this works in our feature article in this issue.

And who knows: maybe future generation spaceships will carry small laser systems that monitor the medical condition of space travelers, providing them with valuable support as they explore distant planets in the infinite vastness of the universe.

Thorsten Naeser
Head of Public Relations

content

Science4People e.V.

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alumni

IMPRS-APS

team news

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research@attoworld

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Center for Molecular Fingerprinting

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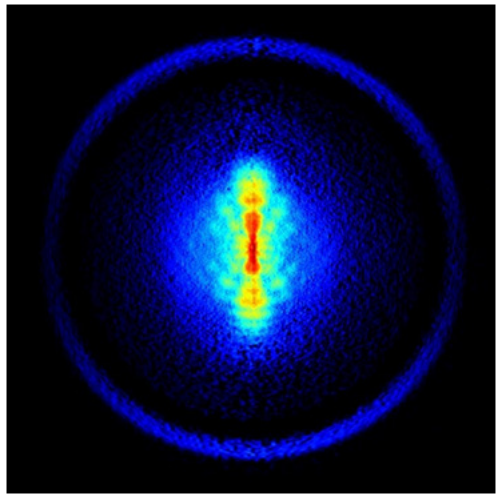
bridging academia and industry

Will I stay in academia or will I move into industry? This is a question many researchers face at some point in their careers, particularly when choosing a path after completing their PhD.



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in neon light – when science becomes art

Brightly shimmering circle in intense shades of blue and violet. At its center lies a radiant core of red, yellow, and turquoise that dissolves outward into concentric zones of color.

84 **photonworld**

portraits of the stars

Photographing the Milky Way from space is something only a few people have managed to do. Astronaut Don Pettit is one of the chosen few.

S4P, founded after the Russia's invasion of Ukraine by Prof. Ferenc Krausz (Nobel Laureate in Physics 2023) is dedicated to improving the educational and developmental opportunities of children and adolescents in war and crisis regions, especially in Ukraine. Many of these children suffer from trauma caused by the ongoing war, leading to significant learning difficulties. Through its projects, Science4People helps them catch up on missed education, supports particularly motivated young people, and promotes sports and arts activities to provide psychological balance.

SCIENCE
4 PEOPLE
Nonprofit Aid Association

crossing borders with SPORT+

November 24, 2025 // Tanya Bergues

A small initiative has grown into a significant branch of the SKOLA+ program of our aid organization Science4People, which is currently operating in Ukraine. In just two years the SPORT+ program has become a great success. It all began with San Sanych, a dedicated coach from the Kherson region who was internally displaced due to the war.

San Sanych started volunteering with ping-pong training sessions twice a week for all interested young people, then continued with volleyball training for children, motivated and convinced of the importance of sport for both physical and mental health, especially in times of crisis.

Training with a pro – twice-weekly sessions for all interested young people.

Stronger together – in the game and in the celebration.
Photos: Tabula Rasa for the Future Generation

What began with one coach quickly evolved. Today, four coaches teach children volleyball, soccer, and handball. Training is full of fun, motivation, and team spirit. Girls and boys teams now participate in competitions across the region. Winning isn't always the goal – yet playing with joy and giving their all always is!

Recent events show just how far SPORT+ has come. The young athletes shone at the '5×5 futsal festival,' competing against eight teams from across Zakarpattia with determination, energy, and teamwork. The girls' volleyball team dominated the first round of regional competitions, fighting for every ball and showcasing incredible cooperation. There is always something happening on the sports fields in Zakarpattia!

First round of the regional volleyball competition.

Active football sessions continue – with new sports equipment for the kids.

5×5 futsal festival

This summer, SPORT+ took another step forward: with support from our local partner 'Tabula Rasa for the Future Generation' and the municipality, we helped create a beach volleyball court. Children and coaches are already enjoying the space, and the first small tournament showed how sport can bring people together.

At Science4People, SPORT+ is much more than physical development. We believe that sport supports mental health, relaxation, motivation, and social cohesion – especially for children experiencing the hardships of war.

Thanks to the integration of SPORT+ into our program, coaches are now compensated for their work, and we provide all the necessary equipment. Our local partner Tabula Rasa for the Future Generation ensures that children have access to structured, safe, and inspiring sports activities. They regularly share updates and photos, allowing us to track progress and celebrate achievements on the ground.

Crossing borders, we combine efforts from Germany and Ukraine to bring opportunities, joy, and growth to children facing extraordinary challenges every day. We are full of ideas for the future and excited to see how SKOLA+ and SPORT+ will continue to grow – perhaps ART+, perhaps STEM+. The possibilities are endless, and we can't wait to share the next chapter of this journey with you. Until next time!

Our new beach volleyball court.

A new space for sport and connection.

general questions and donations:

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science4people.org

no child is a stranger

give the gift of a Christmas miracle!

December 17, 2025 // Tanya Bergues

Besides our long-standing projects SKOLA+ and SPORT+, Science4People e.V. carried out a special Christmas campaign in 2025 that has now successfully come to an end.

In the region where we implement our projects, there is a children's home caring for 60 children. Our partner *Tabula Rasa for the Future Generation* brought it to our attention and, together with the youth center *Zdybanka,* has been supporting the home for many years. Science4People has joined this tradition, providing donations, toys, and Christmas gifts in the past.

This time, with the active support of Science4People, together with Tabula Rasa, the youth center Zdybanka, and in collaboration with the Academy of Culture and Arts as well as the Representation of the Ombudsman in Transcarpathia, an extraordinary Christmas celebration was held for the children.

The festive day included music, lights, and a stage performance featuring a theater production and traditional Christmas carols. A shared Christmas meal created a warm, family-like atmosphere, while personal gifts and essential winter clothing brought comfort and joy during the cold season.

We would like to thank everyone who contributed and helped bring so much joy to the children.

While this project has now come to a close, many more initiatives are planned for the future. We warmly invite our readers to continue supporting projects that bring lasting positive change to the lives of children and communities in need.

Christmas party at the childrens home in Batiovo.

protecting.health global initiative:

toward personalized preventive medicine at the population scale

November 11, 2025 // Dr. Min Kim

What if a routine blood draw could quietly flag early risks for the world's most common diseases – long before symptoms appear? That's the ambition of the protecting.health global initiative, a multi-country program led by Prof. Ferenc Krausz and an international network of scientists, clinicians, and data experts. The vision is simple: build the first large-scale health screening that works across ages, ethnicities, and countries by reading the body's "molecular fingerprints" in blood and interpreting them with advanced AI. Instead of waiting until clinical symptoms are well manifested for treatment, the protecting.health global initiative empowers people and their doctors to act sooner. This allows for early interventions, such as lifestyle changes instead of costly drug therapy, to make a big difference.

The idea in plain terms

Non-communicable diseases (NCDs) – cardiovascular disease, cancers, chronic respiratory disease, and diabetes – are the leading cause of death globally, responsible for *41 million deaths per year.* These illnesses often develop silently. By the time symptoms drive someone to the clinic, important opportunities for prevention may have passed. *protecting.health* aims to flip that script by shifting care from reactive treatment to proactive health maintenance. The program builds a *personal baseline* for each participant from their blood and health information, then watches for gentle drifts over time. When a change appears outside someone's usual range, it can serve as an *early signal* that a disease process may be starting, well before a diagnosis is made. This builds on earlier work showing that a single infrared reading of blood plasma, paired with machine learning, can screen for several health states at once. *protecting.health* takes that approach bigger and deeper.

Prof. Ferenc Krausz giving his inaugural Lecture at the University of Hong Kong (HKU) on November 7, 2025.
Image: HKU

How it will work

Each participating country will enroll *up to 15,000 adults, initially free of NCDs,* and follow them for ≥ *10 years.* Under standardized protocols, *blood samples* and *health data* will be collected every six months. Plasma and linked clinical data will be transferred to the *Molecular Phenotyping Center (MPC),* co-hosted by Budapest and Munich, for unified analysis. There, teams integrate results from multiple measurement platforms and apply state-of-the-art AI methods. The goal is to uncover *reliable molecular patterns* in blood that predict a shift from health toward disease at the *preclinical* stage.

The study begins with a *high-frequency phase:* four "baseline" visits in the first four months establish each participant's person-specific molecular range. Thereafter, *semi-annual check-ins* enable early detection of *small but meaningful deviations* – the moment when tiny drifts matter most. Two cohorts run in parallel: a *lower-risk* group representing the general (relatively healthy) population and a *higher-risk* group that helps accelerate the discovery of early markers. Together, they create a balanced, real-world picture of health trajectories.

What will be measured

Blood plasma is examined by *four next-generation platforms:*

- **EMF** (Electric-field-resolved Molecular Fingerprinting) for a holistic, high-dynamic-range infrared "fingerprint" that captures the combined behavior of thousands of molecules at once.

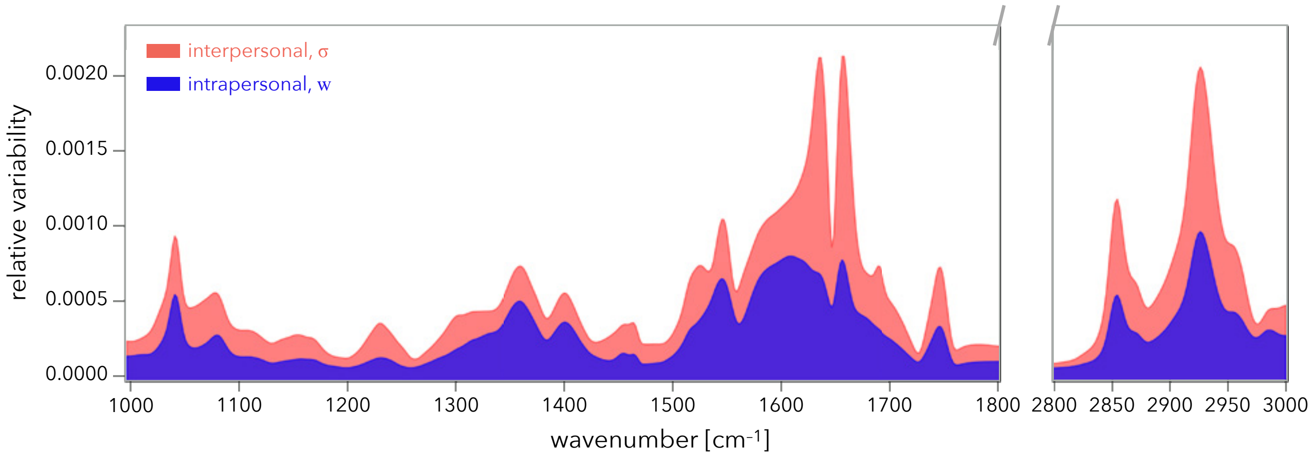
- **Proteomics**, **Metabolomics**, and **Lipidomics** by advanced mass spectrometry and nuclear magnetic resonance that quantify thousands of specific proteins, metabolites, and lipids known to change as diseases develop.

- **FTIR** (Fourier Transform Infrared Spectroscopy) supports quality control and EMF referencing.

By layering these views, the program can link broad, sensitive signals with the specific molecules that may drive them, producing findings that are both *early* and *biologically interpretable.*

Why this design matters

Your biology is uniquely yours, due to genetic makeup, environmental exposures, and stochastic, developmental events. This allows many blood features to be *highly stable within-person*, yet *differ widely between-person*. Traditional disease molecular markers are based on population cutoffs, which means potentially missing early, personal changes. Comparing you to *your own baseline* makes the signal clearer and provides an earlier alert. Ongoing multi-year H4H study program with thousands of volunteers participating supports this concept, showing consistently lower *within-person variability* than *between-person variability* across over a thousand infrared features. In plain language: the body keeps its own steady rhythm, and departures from that rhythm are often more informative than comparisons to strangers.



A plasma infrared fingerprint plot showing smaller intrapersonal variability (blue) than interpersonal variability (red).
Figure: Dr. Kosmas Kepesidis

What success looks like

If *protecting.health* meets its goals, routine visits could become a quiet safety net. A small blood draw and a few minutes of questions might reveal a *risk trajectory* early enough for simple steps – dietary tweaks, exercise plans, medication adjustments, or targeted screening – to change the course. For populations, that means more healthy years. For clinicians, it means better-timed decisions with clearer evidence. For health systems, it means fewer late-stage crises and lower downstream costs. And for science, it means a durable global platform where discoveries move quickly from research to real-world care.

From one drop to a global screen

protecting.health builds on the infrared-plus-AI approach already demonstrated in smaller studies and scales it across continents with denser data and longer follow-up. The project also charts a path to **PH1.0**, an initial clinical-grade health screening tool designed to be practical and affordable to many different healthcare settings. Overall, *protecting.health* wants to build a world where preventive, *personalized* care is part of everyday life, and where the *earliest indication* of disease is noticed, long before it becomes costly to treat or irreversible.

Initiation of protecting.health/Hong Kong, with Prof. Dennis Ip (bottom right) as Chief Clinical Investigator and Yan So (bottom left) as one of HKU's key members supporting the initiative, alongside HKU's Clinical Trial Center.
Image: Adrienn Dávid

Hong Kong: The First Hub for *protecting.health*

protecting.health is launching in Hong Kong in collaboration with the University of Hong Kong (HKU). The city's role came into focus on 7 November 2025, when Nobel Laureate Prof. Ferenc Krausz – newly appointed Chair Professor in HKU's Department of Physics – delivered his inaugural lecture, 'Toward Affordable Preventive Healthcare: Basic Science Addressing Grand Challenges,' to an audience of more than 800 at the Grand Hall, 'Lee Shau Kee Lecture Centre'. The talk focused on pivoting healthcare toward precision prevention care, enabled by state-of-the-art measurement techniques such as field-resolved infrared spectroscopy, which can potentially reveal early molecular changes long before clinical symptoms appear.

The event also signaled strong institutional and civic support: HKU President Prof. Xiang Zhang welcomed Prof. Ferenc Krausz, and Hong Kong's Secretary for Labour and Welfare, Mr. Chris Sun, and Secretary for Education, Dr. Choi Yuk-lin, attended – underscoring the city's ambition to be a global magnet for translational science. Building on this momentum, the newly established 'Institute of Precision Prevention' at HKU will anchor the Hong Kong hub of *protecting.health*, assembling a regional network of clinical study centers and a secure phenotyping/data pipeline that connects to the international consortium – so that early molecular signals can translate into earlier, better care across Asia and beyond.

HKU joins the protecting.health global initiative with the aim to pioneer a new era of preventive medicine.
Image: Adrienn Dávid

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coming soon: **protecting.health**

“I see a parallel between how computers and lasers evolved.”

[Prof. Kafai Mak]

October 10, 2025 // Thorsten Naeser

This summer, Prof. Kafai Mak left the ATTOWORLD-team to move to China. He is now conducting research at Huazhong University of Science and Technology in Wuhan. Here he reports from China. In this interview with Thorsten Naeser, he talks about what he is currently working on, what it is like to live in a metropolis of 13.7 million inhabitants in the middle of the Middle Kingdom, and the differences between life as a researcher in Germany and China.

Dear Kafai, you have now been at your new workplace in Wuhan for several months. Have you already acclimatized to your new living conditions? What are the differences in everyday life between a large Chinese city and the rather tranquil Munich?

There is still a lot to get used to here, but I am gradually settling down into this bustling town. Things can be done quickly in a densely populated city. For example, after contacting the local Telecom for the first time, I have a technician installing my internet at home within three hours, using a new router I bought immediately and separately via a food-delivery-like service. And regarding food, although Wuhan is not as international as cities like Shanghai or Munich, one can still find a lot of different flavors, especially from across the vast country. But I still have to get used to the heat here. Not only the spiciness of the food, but also the outside temperature, which approaches (and on paved roads exceeds) 40° Celsius during peak summer. Fortunately, it has now reverted to a very comfortable 28 degrees in October.

You are now conducting research as a professor at Huazhong University of Science and Technology in Wuhan. What are you working on?

I am currently setting up my lab space and I plan to work on new sources of femtosecond lasers, in a bid to make them smaller, cheaper, and more accessible. This could be on newer platforms such as being on-chip.

Are there any differences between life as a researcher at a Chinese university and at the Max Planck Institute of Quantum Optics?

The working culture is a bit different. Because most work-related communication – even those that are not with close colleagues – are done through WeChat (Whatsapp equivalent), information flows much faster. For simple questions, one can get a reply quickly, or get referred to the person with the answers quickly and move on with the task. It is uncommon to have to wait three working days after sending an email only to be told you asked the wrong person. The downside is that the expectation to quickly respond to others can be disruptive for those who prefer to work alone and distraction-free. It is a small sacrifice for each individual, but the entire system, in which everyone has a stake, runs more smoothly and efficiently when everyone is more responsive.

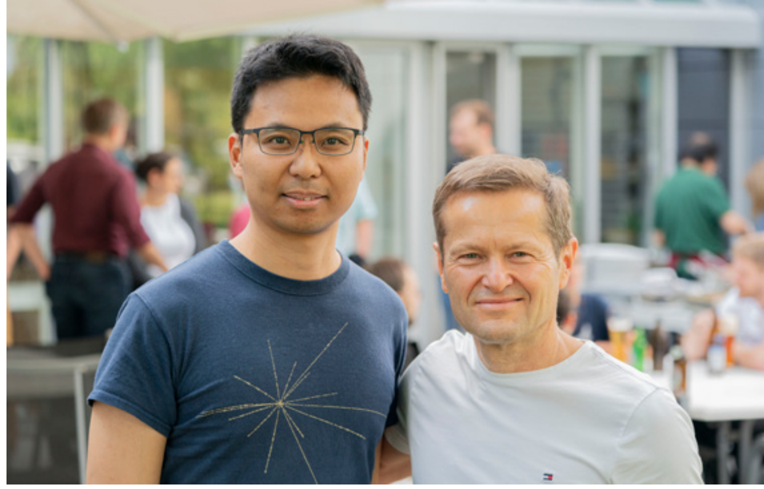

Photo: Thorsten Naeser

Are you planning to collaborate with your former colleagues at the Max Planck Institute of Quantum Optics?

Absolutely! My wish is to continue my previous work carried out at the MPQ, i.e. building femtosecond lasers for the mid-IR wavelength region, and to look for ways to improve their parameters, including costs. As the group at the MPQ continues to advance toward ultrasensitive spectroscopy, the possibly cheaper and better femtosecond laser sources could contribute to the wider adoption of the new spectroscopy techniques.

New arrival at the Wuhan National Laboratory for Optoelectronics. Image: Dr. Qingzhe Cui

Where do you see technology heading in relation to your work in laser development? What is your vision for the future?

I see a parallel between how computers and lasers evolved. From main-frame computer only available to governments and the biggest corporations, to micro-computer for smaller businesses doing accounting, to PCs where people can read news and play games, to a smartphone that fits into your pocket with which you can translate foreign languages on the fly, a wider population and more applications emerged as the technology is miniaturized and costs brought down.

Currently, ultrafast lasers have reached the state where small-medium size companies can afford them. But one day, such lasers will become so small, so cheap, and so ubiquitous that they enable consumer applications beyond our current imagination (I doubt Theodore Maiman – the inventor of the laser – envisioned the game of lasertag). In the future, perhaps one could use their laser-embedded phone to analyze and evaluate a bottle of vintage wine at a wine market; or to capture the chemical signature and thereby recreate an alluring scent; or to take a molecular fingerprint measurement every morning and monitor one’s own health as easily as how we weigh ourselves today. I believe the key to all these rest on making the technology reliable, small, and affordable.

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“I want the laboratory to be like a conveyor belt of challenges.”

[Prof. Adrian Cavalieri]

October 17, 2025 // Nina Beier

This year's ATTOWORLD-retreat was the perfect place to meet many of our alumni. We took the opportunity to sit down with one of them, Prof. Adrian Cavalieri. Back in the days – between 2005 and 2009 – Adrian Cavalieri was a postdoc with ATTOWORLD at MPQ. Today, he is a professor of Physics and the director of the Institute of Applied Physics at the University of Bern. He is also the head of the Laboratory for Nonlinear Optics at the Paul Scherrer Institute, where he oversees the development of optical lasers for the Swiss X-ray Free-electron Laser, SwissFEL, and is pioneering a new beamline, Diavolezza, dedicated to hard-X-ray attosecond science.

What drew you to pursue research with X-ray free-electron lasers?

The time at MPQ, between 2005 and 2009, was one of the most exciting periods in my life. Everything was new. I had just moved from the U.S. to Europe to learn and work in the emerging field of attosecond science. The atmosphere was full of energy. By 2009, we had refined the instrumentation and methodology to the point where we had the possibility to trace electronic dynamics in materials in real time. But what we saw was that the wavelength and intensity of our attosecond pulses restricted the types of systems we could look at. In principle, we've solved those problems with the X-ray free-electron laser, because here you have unlimited intensity and unlimited photon energy … this is what drew me to the FELs … but using these sources in attosecond experiments is still tricky. At SwissFEL, we've spent a lot of time trying to manipulate the X-ray emission so that we can actually make attosecond pulses. Now we are developing the instrumentation to be able to use them.

Following your time at ATTOWORLD, you first went to Hamburg, also working with X-ray free electron lasers. What motivated you to go to Switzerland in 2019?

In Hamburg, at the Max Planck Institute for the Structure and Dynamics of Matter and at the Center for Free Electron Laser Science, I began working to extend attosecond spectroscopy from the table-top to large-scale X-ray free-electron lasers. Although these facilities were still relatively new, they showed the potential to generate intense attosecond pulses deep into the hard X-ray regime. However, despite being located on the same campus with the FLASH VUV free-electron laser and the European X-ray Free-Electron Laser, there were limits to what could be achieved as an experimental “user” of these facilities. In Switzerland, with my joint position, I hoped that I would have the opportunity to influence the scientific direction at the SwissFEL free electron laser toward attosecond science.

Photo: Thorsten Naeser

What is the scientific direction you are aiming for at SwissFEL?

The end goal for me would be using X-rays to probe field-driven dynamics with sub-cycle optical resolution. I want the laboratory to be like a conveyor belt of challenges: We see something interesting happening in the lab with optical or table-top attosecond techniques in an interesting material that could have some functional aspect. Then I want to see that same thing in the beamline that we're building at SwissFEL, and I want to be able to tailor the instrumentation at the beamline specifically to look at that particular problem in greater detail.

What's your vision for the future for the interface between X-ray free-electron lasers and attosecond spectroscopy?

I think that there will be classes of problems that we tackle at the FEL where the dynamics truly unfold on the attosecond timescale. But there will also be classes of problems where we capitalize on the techniques of attosecond spectroscopy, but then work in a femtosecond time domain. All of these things kind of go together hand in hand. If we're looking at a particular system – the energy scales, time scales and length scales – they're all kind of working together so that you have different optical and X-ray wavelengths to match different excitations, whether your sample is a solid or a molecule or an atom. And then we'll have different time scales. But I think that the experimental approaches will rely on the methods, especially photoelectron streaking, that Ferenc pioneered for attosecond spectroscopy.

Did the 2023 Nobel Prize have any impact on your work?

The Nobel Prize clearly raised the profile of attosecond science in the community. General interest in the field is essential for us at large-scale facilities like SwissFEL where access to the machine is precious and resources can be limited due to the complexity of the instrumentation we need. I believe the Prize came at a critical juncture for us at SwissFEL, as it was awarded when we were just starting to build Diavolezza, a new beamline dedicated to attosecond and FEL science (all beamlines at SwissFEL are named for mountain passes).

Is there currently collaboration with the ATTOWORLD team?

FEL experiments require relatively large teams with diverse expertise to run the machine and conduct the experiment. Typically, as users, we get access to the FEL once or twice a year for a ‘beamtime’ that lasts 5 days and runs 24 hours per day. Beamtime is intense, conditions are often changing, and the facilities are always advancing, rapidly adding new scientific capabilities. In the attosecond experiments we've done, it's been crucial to have experts in the field who've seen similar situations in the past – so we've worked closely with the ATTOWORLD-team for over a decade. Unfortunately, these ties have become weaker as a consequence of the global pandemic, which coincided with my move to Switzerland. With Diavolezza scheduled for first light in August 2026, we have the perfect opportunity to strengthen our collaboration again and I'm excited about the future of attosecond XFELs as powerful tools for scientific discovery.

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FLASH: laser physics on the bright side

November 3, 2025 // Dr. Marcus Seidel

After working for five years at Max Planck Institute of Quantum Optics (MPQ), our former colleague Dr. Marcus Seidel joined the Technology Group at the Deutsche Elektronen-Synchrotron (DESY) and worked on the development of pump-probe lasers for FLASH. Since February 2023, he is a junior research group leader at DESY and the Helmholtz Institute Jena. Here he compares, among other things, the laser development at the two German scientific heavyweights.

FLASH is one of two X-ray free electron lasers (XFELs) in Hamburg. It is a user facility where scientists can apply for one-week beam times twice a year by submitting research proposals. FLASH welcomes different user communities ranging from atomic and molecular physics to the solid-state or quantum material field to chemistry and biology. Currently, the facility is about to complete a major upgrade from pure self-amplification of spontaneous emission (SASE) to partially seeded operation. After the upgrade, FLASH will be the only XFEL worldwide which operates externally seeded at kilohertz repetition rate. While it is debatable whether XFELs should be called lasers (where is the inversion?), they present undoubtably the brightest X-ray sources on earth.
For seeding, a widely tunable high-power femtosecond ultraviolet (UV) laser is in its commissioning phase. It is another crucial 'optical laser' that forms an essential constituent of state-of-the-art XFELs. Figure 2 gives an overview about all the ultrafast lasers that are already in operation at the facility or are presently under development. They cover a wide pulse parameter range as they are used in largely diverse applications. At first, electrons are generated by a picosecond UV laser. This so-called photocathode laser determines the minimum emittance of the accelerated electrons, which is comparable to the M^2 of a laser beam.

At an early stage of their acceleration, the electrons interact with another laser, called laser heater. Today, the laser heater plays an essential role in generating few femtosecond or even attosecond pulses with microjoule energies and up to terawatts of peak power in the hard X-ray region. With extreme UV and soft X-ray radiation, core levels of the atoms in the samples under test can be directly probed, making optical pump – XFEL probe experiments site- or atom-specific. Owing to the importance of the optical pump-probe lasers, there is a continuous endeavor to make them more flexible in terms of central wavelength and pulse duration.

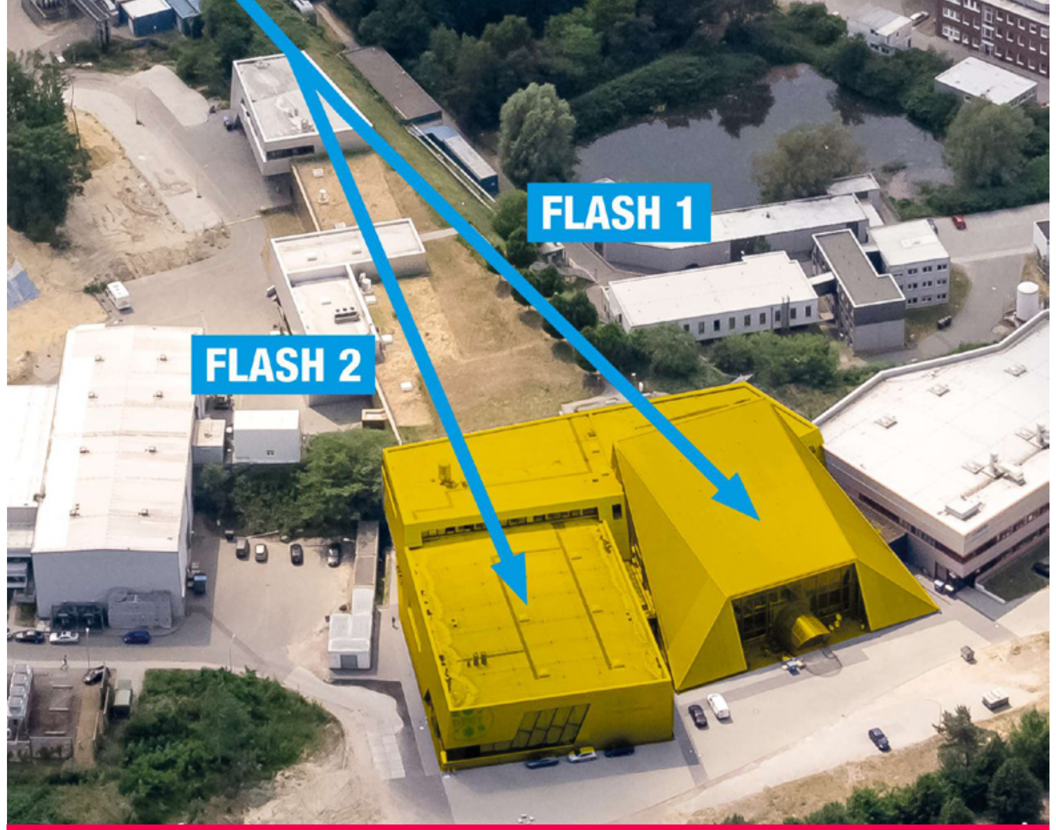

Figure 1: Bird's view onto the DESY campus in Hamburg. The FLASH facility is highlighted. Image: ©DESY

Synchronization of all lasers with the electrons and XFEL radiation, respectively, is obviously a crucial and likewise challenging task. Advanced radio frequency and optical technologies push the synchronization limits today to ten(s) of femtoseconds being particularly impressive in consideration the electron accelerator size. Laser (4) in Figure 2 is currently at an early research and development phase. The scientific perspectives are very exciting though: Optical modulation of electrons can enable the generation intense sub-100 as X-ray pulses. For this purpose, carrier-envelope-phase-stabilized sub-two-cycle pulses with mJ energies would need to be transported into the radiative accelerator tunnel to precisely interact with the relativistic electrons.

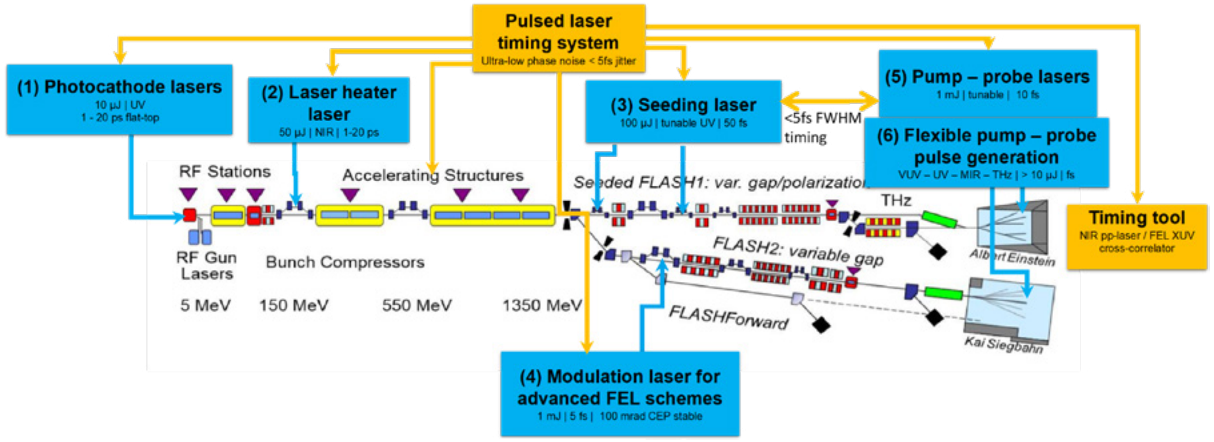

Figure 2: Layout of the XFEL FLASH comprised of gun, bunch compressor, accelerator, the two undulator sequences FLASH1 and FLASH2, generating the X-rays, as well as the corresponding experimental halls. In addition, the optical lasers are described in the blue and yellow boxes. The arrows show at which part of FLASH they contribute or will potentially contribute to the XFEL operation. (source: ref. 1)

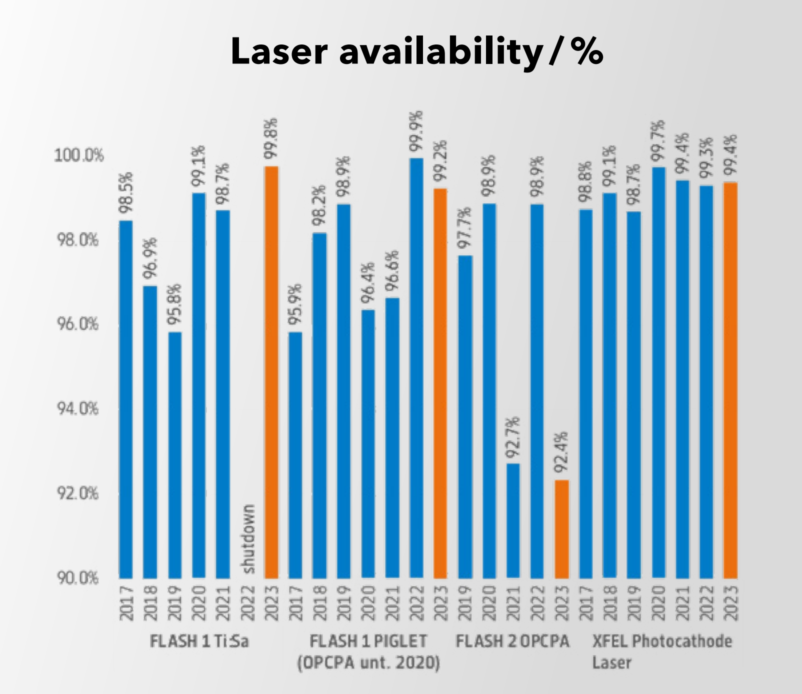

Figure 3: Availability to users statistics for pump-probe lasers (FLASH1 Ti:Sa, FLASH 1 PIGLET, FLASH 2 OPCPA) and European XFEL photocathode laser (operated at the DESY campus) as of 02/2024. Courtesy: Federico Pressaco & Ingmar Hartl

The combination of 'few-cycle', 'carrier-envelope-phase' and 'attoseconds' certainly sounds like music in the ears of many readers connected to the **ATTOWORLD**-team. Therefore, after working (at least) for five years at MPQ and for five years at DESY, I would like to compare laser development at the two German scientific heavyweights a bit. While we pushed the frontiers of laser technology at MPQ to enable pivotal research in the follow-up experiments of our colleagues and us, the developments at DESY have the prior goal that the facility users achieve groundbreaking scientific results with the lasers (and mainly XFELs) during their tightly timed experimental campaigns. These usually include three shifts per day in 24/7 operation. In turn, ultrafast lasers are developed towards ultimate reliability and not necessarily to explore new world-record parameter regimes. In the past years, all lasers were available to the facility users more than 90 % of their beam times (Figure 3). In 2023, the FLASH 1 PIGLET and the XFEL Photocathode laser had over 99 % availability while they were running over 6,000 hours. The so-called PIGLET laser connects also to the skills I acquired during my PhD research at the **ATTOWORLD** which involved to a significant share the technique of nonlinear pulse compression.

PIGLET is the first pump-probe laser at the facility which solely relies on the multi-pass-cell (MPC) technology for ultrashort pulse generation. Figure 4 shows the compact MPC which is in operation at FLASH1 since October 2020. It is comprised of two spherical mirrors and a sequence of three 1 mm thin silica plates. It reduces the bandwidth limit of the pulses emerging from an Yb:YAG amplifier from about 1 ps to sub-60 fs. We called the distribution of the nonlinearity over several thin plates the 'hybrid multi-pass multi-plate' scheme. It enabled record-high single-stage pulse compression factors from 1.2 ps to sub-40 fs and octave-spanning spectra as well as the entrance to the few-cycle regime by means of a double-stage setup.

Optical technology is today absolutely essential at XFEL facilities. It is continuously extending the XFEL parameter and application range. The further advance of femtosecond laser technology towards higher peak and (much) higher average powers, may eventually even replace the hundreds of meters long radio-frequency accelerators by compact laser-based accelerators.

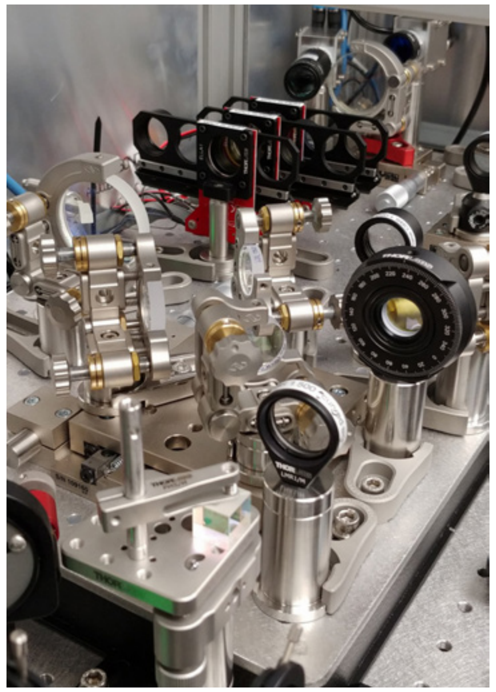

Figure 4: Photograph of the PIGLET laser's compact multi-pass cell.
Image: © DESY

Explore a virtual tour through FLASH:

vtour.desy.de/desytour/index_en.html#node5

original publications:

FLASH2020+ – upgrade of FLASH: conceptual design report
AUTHORS: M. Beye, S. Klumpp, B. Faatz, I. Hartl, C. Lechner, E. Ploenjes-Palm, E. A. Schneidmiller, S. Schreiber, K. Tiedtke, R. Treusch, M. Yurkov, W. Wurth & S. Duesterer
PUBLISHER: ***Deutsches Elektronen-Synchrotron Hamburg***, (2020), ISBN: 9783945931301

ultrafast MHz-rate burst-mode pump-probe laser for the FLASH FEL facility based on nonlinear compression of ps-level pulses from an Yb-amplifier chain
AUTHORS: M. Seidel, F. Pressacco, O. Akcaalan, T. Binhammer, J. Darvill, N. Ekanayake, M. Frede, U. Grosse-Wortmann, M. Heber & C. M. Heyl et al.
JOURNAL: ***Laser Photonics Reviews* 16**, 2100268 (2022)

few-cycle pulse generation by double-stage hybrid multi-pass multi-plate nonlinear pulse compression
AUTHORS: A.-L. Viotti, C. Li, G. Arisholm, L. Winkelmann, I. Hartl, C. M. Heyl & M. Seidel
JOURNAL: ***Optics Letters* 48**, 984 (2023)

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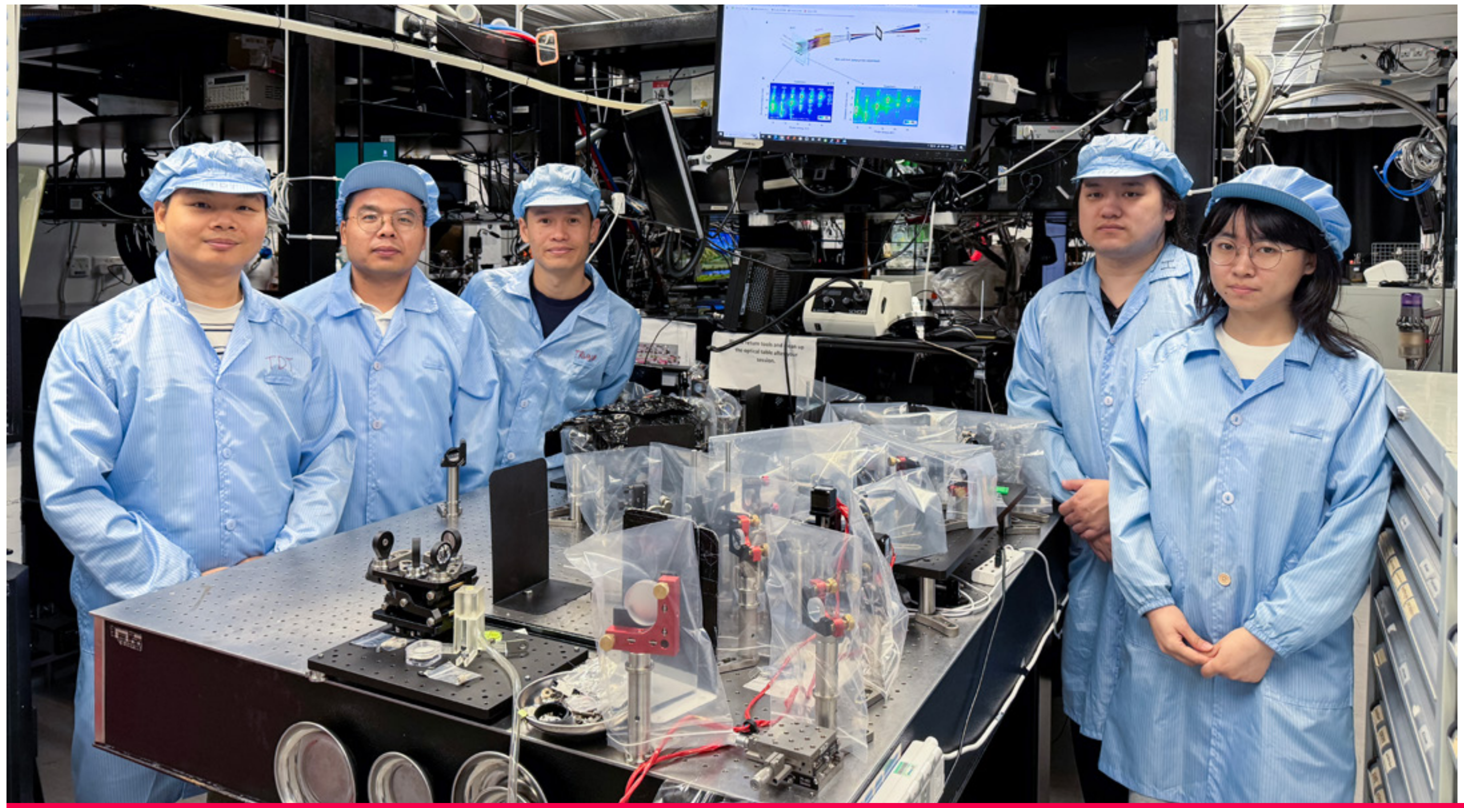
new spectroscopy techniques unveil hidden dynamics in solids

October 22, 2025 // Asst. Prof. Tran Trung Luu

In two groundbreaking studies published in Nature Photonics and Nature Communications, Dr. Tran Trung Luu and collaborators from the Laboratory for Ultrafast Optics and Attosecond Science, Department of Physics at the University of Hong Kong, have unveiled powerful new methods to probe and control ultrafast dynamics in solid-state materials, opening new frontiers in quantum materials research and optoelectronic technologies.



The team behind the works in Ultrafast Optics and Attosecond Science Laboratory in The University of Hong Kong. From left: Tien-Dat Tran, Jicai Zhang, Tran Trung Luu, Wenhao Yu, Ziwen Wang. Photo: Jiaqi Xu

In the study ‘High-harmonic spectroscopy probes lattice dynamics’, published in Nature Photonics, the team demonstrates how high-harmonic spectroscopy (HHS) can be used to directly observe electron–phonon and anharmonic phonon–phonon interactions in real time. By applying ultrashort laser pulses to α-quartz crystals, the researchers captured coherent lattice vibrations with unprecedented sensitivity and temporal resolution.

Using a novel time-windowed Gabor analysis, the physicists successfully identified channel-resolved four-phonon scattering processes, revealing atomic displacements on the scale of tens of picometers. This technique provides a background-free, energy-domain approach to studying fundamental interactions in solids, offering a new benchmark for ab initio calculations and advancing our understanding of thermal conductivity, superconductivity, and phonon dynamics.

In a second study (‘Noncollinear harmonic spectroscopy reveals crossover of strong-field effects’), published in Nature Communications, the team introduces noncollinear harmonic spectroscopy, a technique that enables spatiotemporal control of electron dynamics in materials like silicon dioxide (SiO_2). By precisely tuning the interaction of light with matter, the researchers observed a crossover between key strong-field phenomena, including the AC Stark effect, dynamical Franz-Keldysh effect, and ponderomotive shifts.

This method allows for momentum- and parity-resolved measurements of ultrafast carrier dynamics, offering a powerful tool for tailoring electronic and excitonic states in quantum materials. The findings pave the way for next-generation optoelectronic and nanophotonic devices, where femtosecond-scale control of material properties is essential.

Both studies represent a significant leap forward in our ability to observe and manipulate the ultrafast processes that govern the behavior of quantum materials. By combining advanced spectroscopy with theoretical modeling, we’re opening new doors to control matter at its most fundamental level.

original publications:

high-harmonic spectroscopy probes lattice dynamics
AUTHORS: J. Zhang, Z. Wang, F. Lengers et al.
JOURNAL: ***Nature Photonics* 18**, 792 (2024)

noncollinear harmonic spectroscopy reveals crossover of strong-field effects
AUTHORS: J. Zhang, X. Liu, TD. Tran et al.
JOURNAL: ***Nature Communications* 16**, 7660 (2025)

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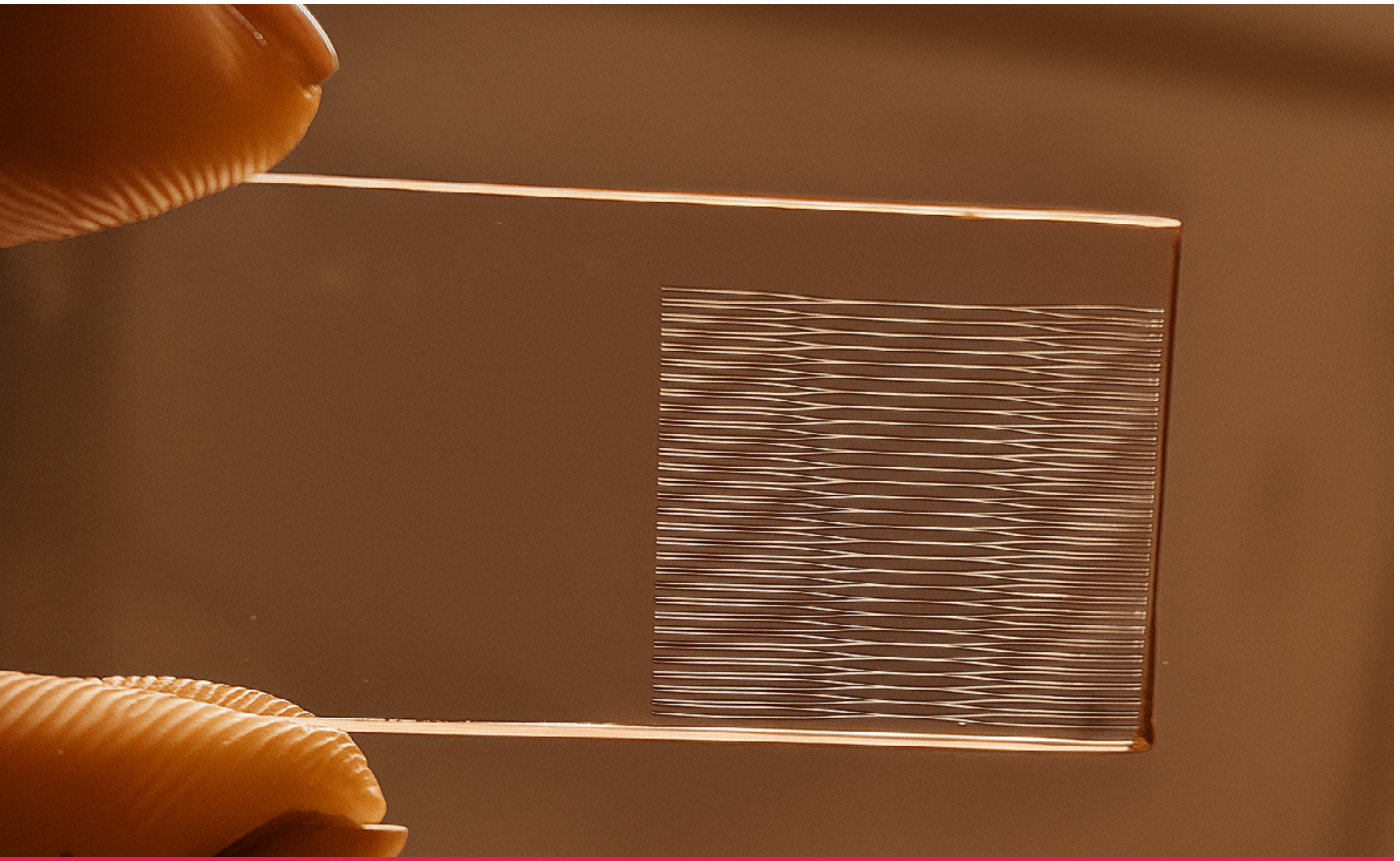
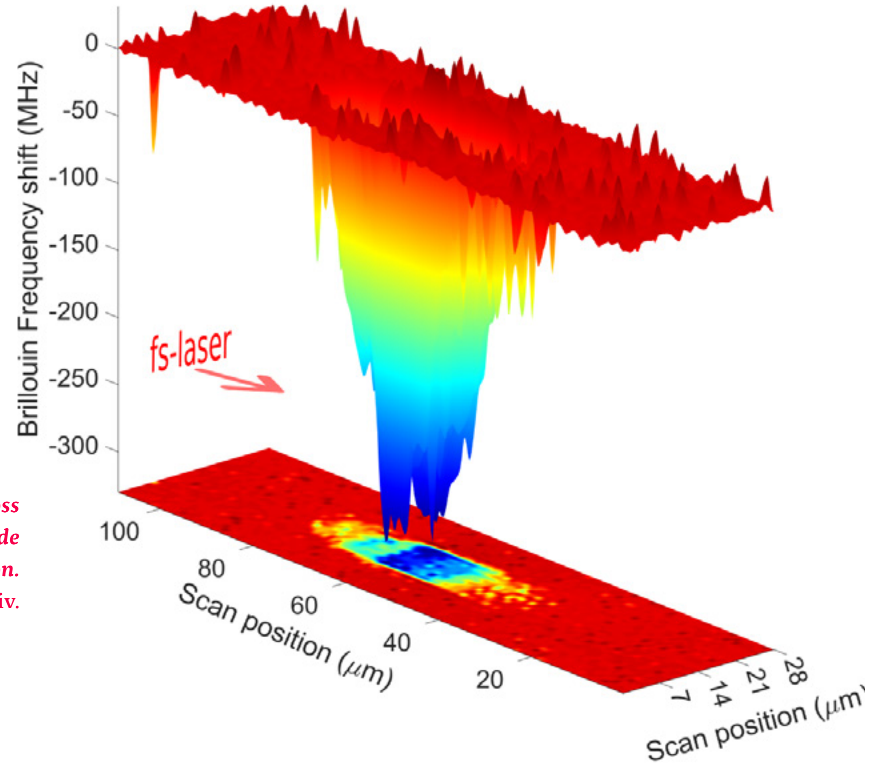
femtosecond laser direct-write photonics

October 23, 2025 // Prof. Alexander Fuerbach

Imagine taking a blank sheet of paper and a pen, drawing a straight line, then extending it into letters, words, and intricate patterns: The creative possibilities quickly become limitless. In Femtosecond Laser Direct-Write (FSLDW) photonics, Prof. Alexander Fuerbach and his team from the Faculty of Science and Engineering Macquarie University, Australia, use a far more sophisticated 'pen': a tightly focused train of ultrashort laser pulses. The 'paper' is not flat but a three-dimensional block of glass that can be translated in any direction, enabling the inscription of truly 3-D photonic circuits from simple straight waveguides ('lines') to complex integrated architectures. Here Alexander Fuerbach reports about this technique.



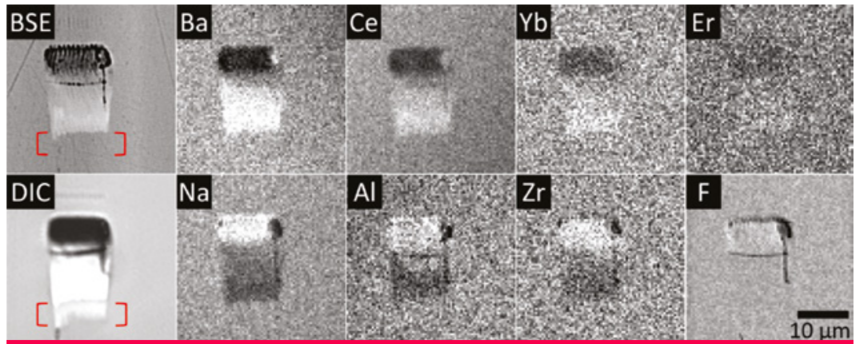
Photograph of an array of femtosecond laser-inscribed evanescent couplers.
Photo: Dr. Toney Fernandez, Adelaide University



Brillouin frequency shift map across a laser-written fluoride-glass waveguide showing strong local densification.
Figure: Dr. Toney Fernandez, Adelaide Univ.

At the heart of this technique lies nonlinear absorption. By concentrating energy both temporally (through femtosecond pulse durations) and spatially (via tight focusing), multiphoton absorption is utilized to transfer energy from the electromagnetic laser field into the material, thus initiating a localised and permanent refractive index modification that is strictly confined to the focal volume. This spatial confinement not only enables structuring within the bulk (rather than being limited to surface modification as in lithographic techniques) but also accounts for the high spatial resolution of the process, reaching sub-micron scales, and ultimately enables true three-dimensional photonic fabrication.

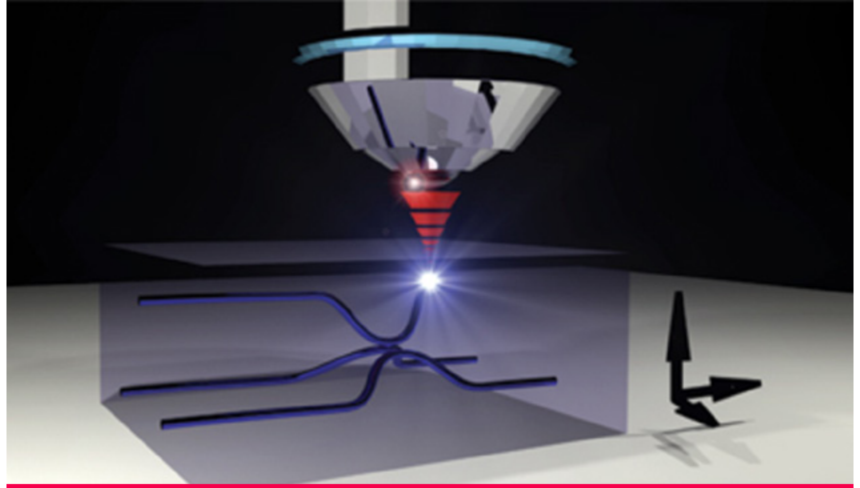
The conceptual principle is as simple as it is elegant, yet the microscopic physical processes that are occurring within the glass and that ultimately result in a stable refractive index change are complex and highly material-dependent. Contributing mechanisms may include selective ion migration, formation of colour centres, laser-induced molecular bond rearrangement, and thermally driven densification, among others. A thorough understanding of these processes is essential to optimise fabrication parameters and to realise low-loss optical circuits with high index contrast capable of supporting tightly confined optical modes. At Macquarie University in Sydney, and with the support of our collaborators in Adelaide, Europe and China, our recent efforts have focused on mid-infrared transparent glasses to harness the vast potential of this spectral region for applications ranging from molecular spectroscopy to sensing and environmental monitoring.



Backscattered electron (BSE) and differential interference contrast (DIC) microscopy images of the waveguide confirm densification. Elemental mapping by electron probe microanalysis (EPMA) reveals selective migration of barium and sodium as the primary contributors.
Figure: Dr. Toney Fernandez, Adelaide University

Unraveling what happens inside a material during femtosecond laser irradiation is very much a detective process. No single diagnostic technique can reveal the full picture; instead, a suite of complementary micro-characterisation methods is required to piece together the underlying mechanisms and to complete the puzzle. We typically begin by utilising Quadri-wave Lateral Shearing Interferometry (QWLSI) to obtain a precise 2-D refractive index profile of a laser-written waveguide's cross-section. Depending on the glass composition, this is then complemented by some of the following techniques: Brillouin microscopy maps the Brillouin frequency shift arising from light-acoustic phonon interactions, providing insight into local changes in physical density and the longitudinal modulus. The latter can be interpreted as an effective interatomic spring constant that directly relates to material polarizability and thus refractive index. Micro-Raman spectroscopy, based on inelastic scattering, reveals the formation of laser-induced color centers and/or molecular bond rearrangements. Finally, electron microscopy techniques such as Back-Scattered Electron (BSE) imaging and Cathodoluminescence (CL) provide additional structural contrast, while Electron Probe Micro-Analysis (EPMA) enables precise mapping of elemental distributions.

By combining these micro-characterisation tools, we recently gained a comprehensive understanding of femtosecond laser-material interaction in fluoride glasses, arguably the most important glass family for applications up to about 7 µm. This insight allowed us not only to optimise the laser processing parameters but to also tailor the glass composition itself, enabling the inscription of waveguides with record-high refractive index contrast $(>10^{-2})$ and ultra-low propagation loss. In other words, we now have both the perfect pen and the perfect paper and can finally let our imagination run wild. The realisation of evanescent coupler chips for fully integrated mid-infrared fibre ring lasers was only a starting point. We are now moving towards the design of complex 3-D photonic architectures, including fully integrated Fourier-transform spectrometers based on spatial heterodyne multiplexing.



Principle of the Femtosecond Laser Direct-Write (FSLDW) technique.
Image: Dr. Martin Ams, Macquarie University

original publications:

soft glass fibre components for mid-infrared lasers and amplifiers: breakthroughs, challenges, and future perspective
AUTHORS: K. Grebnev, B. Perminov, T.T. Fernandez, A. Fuerbach & M. Chernysheva
JOURNAL: ***APL Photonics* 9**, 110901 (2024)

ultrafast laser-fabricated fluoride glass waveguides with exceptionally high positive refractive index change for mid-infrared integrated optics
AUTHORS: T.T. Fernandez, Y. Hwang, H. Mahmodi, D.E. Otten, L. Plenecassagne, S. Cozic, S. Gross, I. Kabakova, M. Withford, M. Poulain, A. Fuerbach & D.G. Lancaster
JOURNAL: ***Optics Express* 32**, 42938 (2024)

thermally stable high numerical aperture integrated waveguides and couplers for the 3 µm wavelength range
AUTHORS: T.T. Fernandez, B. Johnston, H. Mahmodi, K. Privat, I. Kabakova, S. Gross, M.J. Withford & A. Fuerbach
JOURNAL: ***APL Photonics* 7**, 126106 (2022)

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ultrafast quantum optics

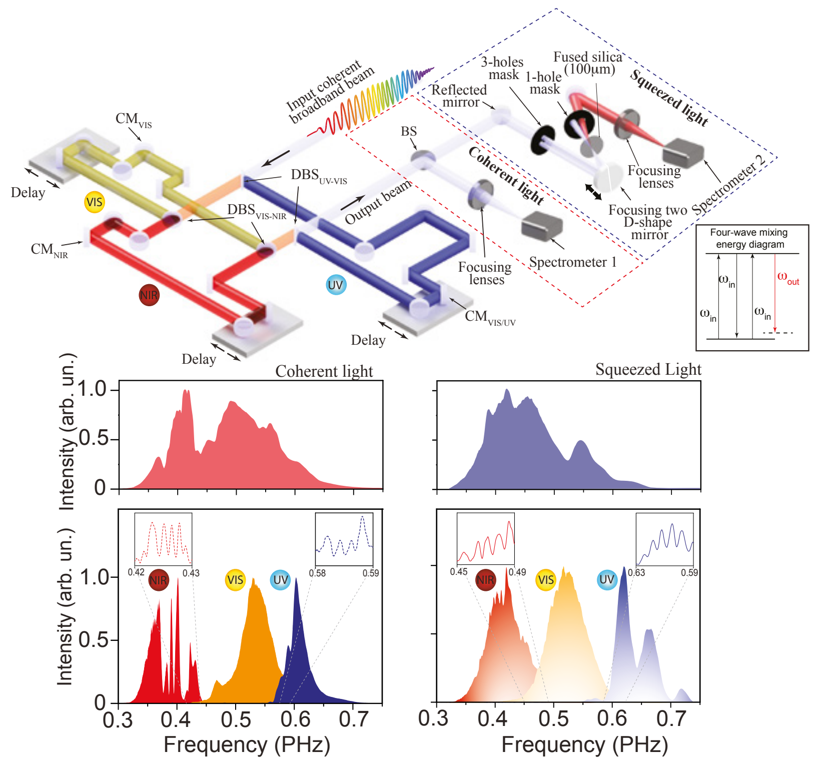
October 15, 2025 // Assoc. Prof. Mohammed Th. Hassan

In a new breakthrough, the research group of Prof. Mohammed Th. Hassan from the Physics Department at the University of Arizona and other collaborators have demonstrated the creation and control of ultrafast squeezed light pulses – quantum light bursts lasting just a few femtoseconds. This breakthrough doesn't merely refine existing quantum technology; it defines the foundation of an entirely new emerging field – ultrafast quantum optics.

At its heart, the research demonstrates the generation of quantum light pulses spanning frequencies between 0.33 and 0.73 petahertz (PHz). These pulses were produced through a degenerate four-wave mixing process, in which multiple laser beams interact within a transparent medium to generate light with uniquely 'squeezed' quantum properties. In squeezed light, quantum noise – an inherent uncertainty of nature – is redistributed so that one property, like amplitude, becomes more precise at the expense of another, like phase.

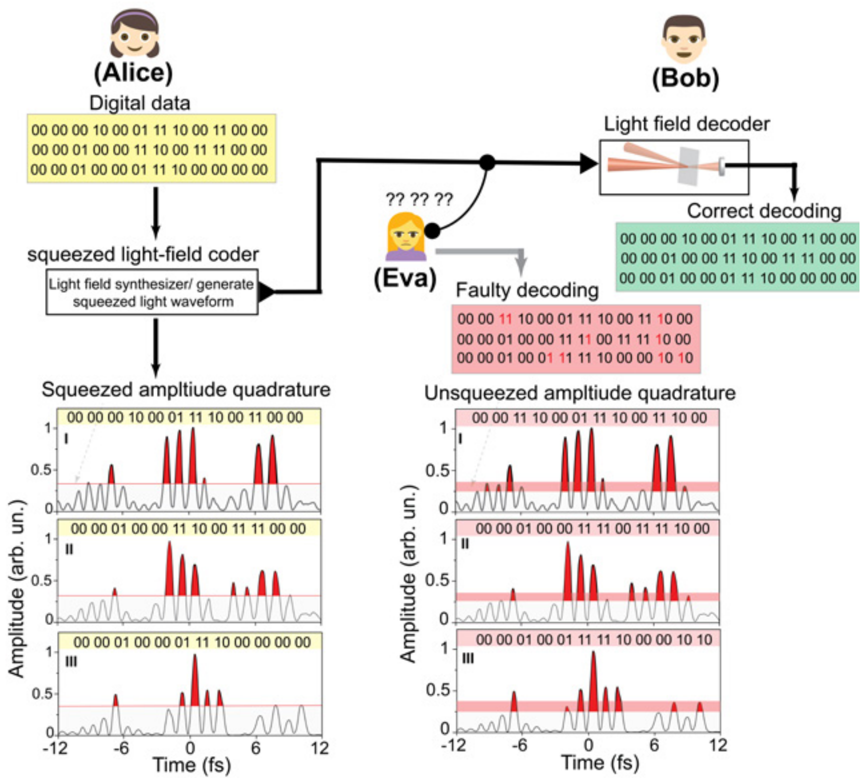
By using the light-field synthesizer that combines ultraviolet, visible, and near-infrared pulses, the team created the *shortest and broadest quantum light pulses ever produced.* They also devised a novel method to measure these fleeting quantum states with attosecond precision, confirming that their light exhibited genuine amplitude squeezing – an unmistakable quantum signature. Theoretical modeling revealed squeezing strengths of up to 13 dB, placing the work among the strongest demonstrations of non-classical light behavior ever recorded.

The ultrafast squeezed light pulses generated by the light field synthesizer.
Figure: Hassan-group

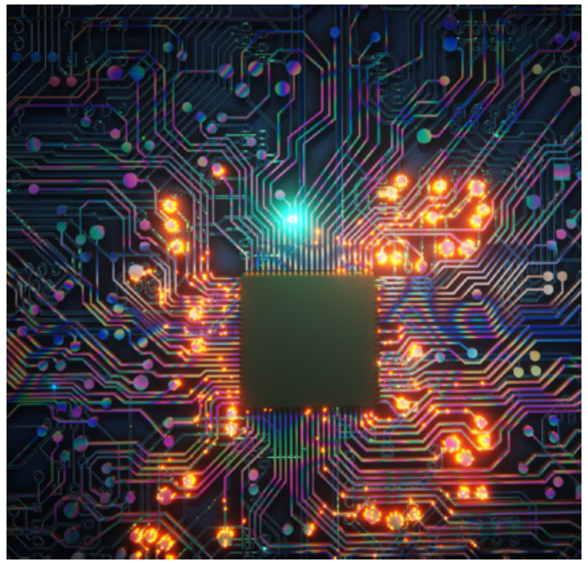


Perhaps most remarkably, the researchers showed for the first time that *quantum uncertainty itself can be dynamically controlled in real time.* By adjusting the timing between the interacting light waves, they observed that the quantum quadratures of light fluctuate and can be tuned at will. This discovery transforms the traditional view of quantum indeterminacy – from a static limit to a manipulable feature – opening the door to ultrafast quantum control.

The study goes beyond fundamental physics, proposing a *petahertz-scale quantum communication system* that encodes digital data directly onto the ultrafast squeezed light waveforms. In this scheme, binary ones and zeros are represented by intensity levels within the quantum field itself, ensuring absolute security: any eavesdropper would inevitably disturb the light's delicate squeezing, revealing their presence instantly.



Ultrafast quantum high secured encrypted communications.
Figure: Hassan-group



The electronic of the future: petahertz quantum optoelectronics
Image: Ella studio

The implications are vast. Ultrafast squeezed light could enable quantum computers that process information on attosecond timescales, or quantum spectroscopes capable of watching electron motion within atoms in real time. It may even lead to *petahertz quantum optoelectronics* – devices that operate a million times faster than today's microchips.

This work, tighter with all the research activities in strong field quantum interaction, marks the birth of ultrafast quantum optics, a discipline uniting the speed of attosecond science with the laws of quantum mechanics. By proving that quantum states of light can be generated, measured, and controlled on attosecond timescales, this research lays the groundwork for the next generation of quantum technologies – faster, more secure, and more fundamental than anything before.

original publication:

attosecond quantum uncertainty dynamics and ultrafast squeezed light for quantum communication
AUTHORS: M. Sennary, J. Rivera-Dean, M. El Kabbash, V. Pervak, M. Lewenstein & M. Th. Hassan
JOURNAL: ***Light: Science & Applications* 14**, 350 (2025)

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The 'International Max Planck Research School for Advanced Photon Science' (IMPRS-APS) is a graduate school dedicated to the advancement of photon science, spanning areas such as ultrafast laser science, attosecond physics, high-precision spectroscopy, biomedical applications of advanced spectroscopic methods, data science, and laser particle acceleration. Doctoral candidates benefit from extensive training opportunities, including interdisciplinary scientific knowledge, soft skills, industry exposure, and more.

IMPRS-APS

bridging academia and industry

October 16, 2025 // Nina Beier

Will I stay in academia or will I move into industry? This is a question many researchers face at some point in their careers, particularly when choosing a path after completing their PhD. However, during their graduate studies, they often only get to see one side of this coin: the academic one.

At the IMPRS-APS, we want our doctoral candidates to see the whole picture – by also giving them a glimpse into the industry side. This year – thanks to our former and current IMPRS-APS coordinators Lena Beggel and Sibylle Graf – our PhD students had the opportunity to visit not only one, but seven companies.

Oh, and what a range of companies they were – from laser manufacturers 'TRUMPF Scientific Laser' or 'InnoLas Laser' to the fusion startup 'Marvel Fusion', the consultancy 'Basycon', and the patent attorney company 'Grünecker', among others. Fortunately, we often have direct connections at these companies, thanks to our IMPRS-APS and ATTOWORLD-community's widespread network. This allowed our young researchers to tap into the experiences and knowledge of former colleagues who now work at these companies, providing them with a unique opportunity to learn from their peers.

Learning about laser communication at Mynaric. The visit was hosted by IMPRS-APS alumnus Clemens Jakubeit (on the right). Photo: Thorsten Naeser

The informal aspects of our visits, such as coffee breaks and lunches, proved to be the most valuable part of the experience. These relaxed settings allowed our researchers to ask employees a wide range of questions, from everyday life at work and job requirements to technical questions and big-picture discussions about emerging technologies like fusion and laser communication.

The company visits not only serve as a valuable resource for our students to explore potential career paths after their PhD, but also offer a refreshing perspective outside their usual academic bubble. Therefore, in addition to company visits, the IMPRS-APS also organized research visits to institutions like ESO and FRM II, providing a well-rounded insight into interdisciplinary science. We look forward to continuing this initiative next year and invite anyone with ideas or connections to companies to get in touch with Sibylle Graf.

What our doctoral candidates say about our company visits:

"I think that the company visits organized by the IMPRS provide a valuable opportunity for PhDs in all situations.

On the one hand, a new PhD student has the opportunity to gain a great outlook in the field that they just entered. The companies can provide a different perspective than the university or the Max Planck Institute, as they have different aspects that they need to focus on to stay competitive and provide new innovations for new scientific challenges.

On the other hand, a PhD who is close to graduating can get an overview of the different fields where his skills can be applied. As a PhD thesis requires a lot of focus on a specific task at hand, a new challenge and the contact with scientists from other fields as well as different backgrounds can spark new ideas and help overcome known obstacles.

An important aspect for me is the opportunity to connect and interact with other scientists who have more experience and also might have faced similar questions, especially regarding a potential career path, as well as having insights on the day-to-day work at the companies, including the environment in the laboratories."

Benedict Röcken

“In the lab, we build laser systems that break the record of the current technology, but in some sense, it is enough if they work once. Visiting laser companies was a good chance to change a bit the perspective: the main goal shifts from pushing the performance as far as it can get, to the achievement of reliable and stable operation over many years. On the one hand, this helps us to put our research in a proper context, and shows us – among others – what is missing in our work. On the other hand, it is also interesting and motivating to understand where and how the results of our research could be applied in a few years from now.

I think it is a valuable opportunity to get in contact with people working in a somewhat different environment, and reciprocally exchanging a bit of our experience. In this regard, such networking is not so much different from what happens during conferences, in my opinion.”

Marco Dassie

The IMPRS-APS company visits give doctoral candidates insights into various career paths in industry – such as becoming a consultant at ‘Basycon’. Photo: Nina Beier

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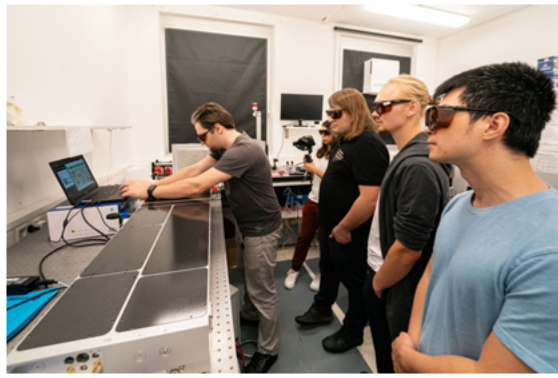
ATTOWORLD-alumnus Tom Metzger showing the students the cleanroom at ‘TRUMPF Scientific Laser’. Photo: Nina Beier



A look into the laser development at ‘InnoLas Laser’. Photo: Thorsten Naeser

During a company visit at ‘Marvel Fusion’, the students had the opportunity to see the startup’s experimental chamber at CALA. Photo: Nina Beier

Informal exchanges during the breaks are usually the most valuable part of the company visits – like here at ‘OmegaLambdaTec’. Photo: Sibylle Graf

Exploring patent law at ‘Grünecker’. Photo: Nina Beier

pioneering data science in healthcare

the John von Neumann Institute of Data Science leads a new era of research and education

October 30, 2025 // data science

A powerful alliance between Semmelweis University and the Center for Molecular Fingerprinting (CMF) is charting new territory at the intersection of healthcare and data science. Their joint venture, the John von Neumann Institute for Data Science, has already been established and is expected to rapidly become a hub for innovation in medical research, education, and technology.

At its core, the institute's mission is ambitious: to transform healthcare through data-driven molecular understanding. By integrating CMF's advanced molecular fingerprinting and profiling technologies into comprehensive health datasets, researchers aim to uncover subtle biological patterns that signal disease long before symptoms appear. This pioneering synergy promises not only earlier detection of conditions that may evolve into chronic diseases, but also a deeper, more holistic view of human health itself.

A new era begins: Semmelweis University & CMF launch the John von Neumann Institute. From left: László Vastag (Managing Director CMF), Béla Merkely (Rector of Semmelweis University), Ferenc Krausz & Kosmas Kepesidis. Photo: © Semmelweis University

In its initial phase, a dedicated research team is laying the foundation for breakthroughs in personalized medicine and predictive healthcare, combining molecular data with advanced analytical methods to reveal new dimensions of biological complexity.

Yet the John von Neumann Institute is more than a center for research – it is also shaping the next generation of scientists and innovators. Its interdisciplinary doctoral program has already been launched, enrolling its first cohort of PhD students. The program brings together graduates from diverse fields such as computer science, statistics, mathematics, physics, and medicine, fostering collaboration across disciplines that are increasingly essential to the future of healthcare.

Read the full article at semmelweis.hu:

pushing the frontiers at the 2025 ATTOWORLD-retreat

October 10, 2025 // Nina Beier & Umai Galadriel Chibbaro Leiva

It's not every year that so many members of our attoworld come together in one place. This year's retreat offered the perfect setting to reconnect – bringing together old friends and new faces at the Max Planck Institute of Quantum Optics in Garching and the Explorer Hotel in Ötztal. Among the 103 participants, we were delighted to welcome 23 alumni who traveled from around the world, from the southern hemisphere to the far north.

The retreat provided a unique platform for our research group leaders to share valuable insights into their work, as well as for eight of our alumni to showcase their current research endeavors. We were excited to have László Veisz, Adrian Cavalieri, Alexander Fuerbach, Peter Baum, Marcus Ossiander, Marcus Seidel, and Péter Dombi present their latest research. Nobel Laureate Ferenc Krausz captured the essence of the workshop when he said, in retrospect, that it should have been titled 'Pushing the Frontiers.' The talks showcased the various frontiers being pushed by members of the ATTOWORLD-community – old and new – from integrated waveguide photonics to the most intense single-cycle light in the world to the electric-field molecular fingerprinting of cancer, and many more.

As in previous years, we also got an update on the PhotonLab – including a hands-on tour of the student lab in their new space – as well as industry insights from UFI and PULSED.

The retreat's informal atmosphere facilitated meaningful discussions and idea-sharing, with coffee breaks, lunch, and dinner providing plenty of opportunities for conversations and exchange. In addition, evening poster sessions offered a glimpse into the latest exciting research from our groups.

Accompanying this was the beautiful scenery of Ötztal, where the surrounding peaks and valleys offered the perfect counterbalance to the week's intense scientific exchange. Between talks and discussions, the team traded lasers and equations for hiking boots and backpacks, setting off to climb the surrounding mountains. These excursions not only tested our physical limits but also mirrored the spirit of the week, pushing both scientific and human frontiers. A must-see was the Stuiben Falls, a breathtaking experience at Tyrol's highest waterfall. The hiking trail led us all the way to the top, where the mist and the view combined perfectly to leave us feeling renewed.

The highlight of the final evening was a concert by the 'PlanckTones', whose lively performance perfectly encapsulated the week's atmosphere. Among the highlights were playful nods to lab life, including the unforgettable '1000 Mal justiert, 1000 Mal ist nichts passiert.' It was a fitting finale to an inspiring retreat, one we hope to repeat next year!

Photos: N. Beier, T. Naeser, Z. Wei, I. Yamnenko & M. Zeuner

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.

CALA

intergalactic dragon boat race

July 7, 2025 // Thorsten Naeser

Members of the Centre for Advanced Laser Applications (CALA) launched themselves into the cosmos at this year's 'Master of the Olympic Lake' dragon boat race, securing a stellar third-place finish while claiming top honors for their out-of-this-world costume design. Held on July 4th at Munich's Olympic Lake, the annual aquatic competition once again brought together teams from Ludwig-Maximilians-Universität München (LMU) and Technical University of Munich (TUM) for an exhilarating day of racing.

Following their successful participations referencing calamari (CALAmari) and colors (CALAful), the team chose a space-inspired theme (InterCALAktisch) for their third partaking in the event. Their custom-made costumes proved to be a universal hit, earning them first place in the creative costume competition, while their athletic performance was also nothing short of astronomical. In their second qualification race, the CALA team was more than three seconds faster than in last year's finals and achieved the fastest time (1:18.0) of the entire day across all competing boats. This remarkable qualifying performance secured their passage to the semi-finals with ease, setting high expectations for the final rounds.

The finals brought intense competition, with CALA maintaining their stellar form to claim a well-deserved third-place finish. While they couldn't quite reach the podium's top tier, their consistent performance throughout the day and over the years showcases the same precision and teamwork that defines their approach to cutting-edge laser research. Adding to CALA's success story, Stefan Karsch once again took to the water in the traditional professors' race between LMU and TUM. Continuing his winning streak, Karsch secured victory for Team LMU, proving that CALA's competitive spirit spans across all levels of the university community. With their strong showing, the CALA team has established itself as a force to be reckoned with in the yearly competition.

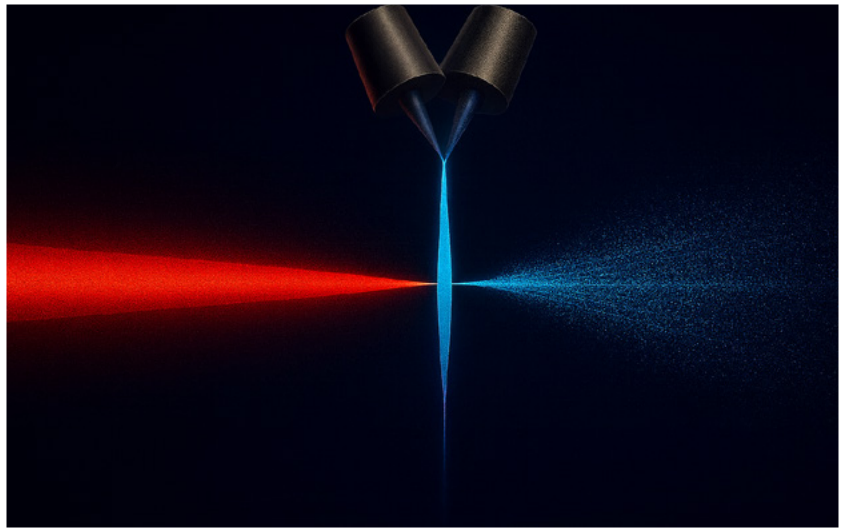
Photo: Thorsten Naeser

fast protons from water

September 12, 2025 // Prof. Jörg Schreiber

Particle acceleration using powerful laser pulses is becoming increasingly important in opening up new avenues for medical and biological applications. To this end, the Centre for Advanced Laser Applications is conducting fundamental research into the conditions under which efficient acceleration of ions, for example for irradiation, is possible.

Strong laser pulses incident from left (red) hit a very thin film of floating water and produce a proton beam (blue). Image: Lianren He



Now, a team led by Prof. Jörg Schreiber has significantly improved the application possibilities of laser plasma acceleration technology for energetic proton bunches. In an experiment, the researchers focused laser pulses from the ATLAS-3000 system onto thin flowing water films using an effect that one sometimes also observes when doing the dishes. This enabled the team to generate up to 400 proton bunches. The goal now is to catch up with the repetition rate of the 27-femtosecond laser pulses at a peak power of over 1,000 TW, that is to generate energetic proton bunches every second.

With their latest light-water interaction experiments, the LION team has achieved proton acceleration at high repetition rates and to velocities enabling radiation chemistry studies that are relevant for example in medicine and biology.

Read more at cala-laser.de:

original publication:

stable high-energy proton acceleration with water-leaf targets driven by intense laser pulses

AUTHORS: L. R. He et al.

JOURNAL: ***Physical Review Research* 7**, 023190 (2025)

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cala-laser.de/experiments/lion

new laser system delivered to CMF laboratory in Szeged

Infrasampler 3.0 successfully installed in ELI-ALPS

November 10, 2025 // D. Bondar, S. Mathani, A. Maity & A. Weigel

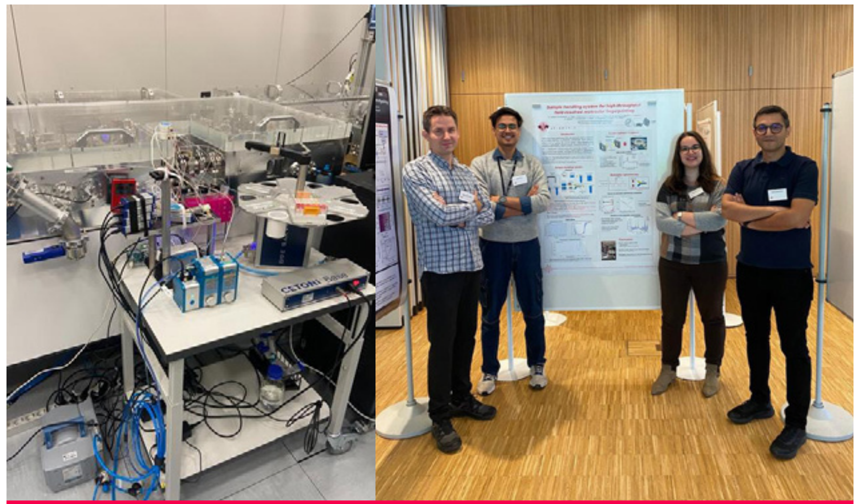
Following our vision to use field-resolved infrared spectroscopy to establish early disease detection based on just a sample of blood, the team around Dr. Alexander Weigel has developed infrared fingerprinting instruments with ever increased sensitivity, spectral coverage and reliability over the last years. In September, a new and enhanced version of the field-resolved spectrometer has been successfully installed at the ELI-ALPS facility in Szeged, Hungary.

The instrument, Infrasampler 3.0, represents an important milestone in the collaboration effort between the CMF, LMU, and MPQ to identify in large-scale blood-sample campaigns infrared fingerprint signatures that correlate with the onset of non-communicable diseases like cancer. The new instrument combines record-high laser stability with two-octave-spanning spectral infrared coverage and an automated sample-handling system using modulation techniques. After its final optimization, Infrasampler 3.0 will be used in 2026 to measure blood samples from the Health for Hungary (H4H) study that follows more than 10,000 voluntary and initially healthy participants for a duration of a decade with regular assessments of the health status and blood collection. Infrared electric field measurements with the new instrument will be analysed and compared using machine-learning techniques to derive fingerprint patterns of developing medically relevant conditions. In future, this may provide the basis for a affordable and generalized approach to health monitoring and early disease detection.

Dominika Bondar working on the new Infrasampler 3.0 System in the in the CMF laboratory at ELI-ALPS in Szeged.
Image: FRIS-group

A first version of the field-resolved infrared spectrometer, Infrasampler 1.5, was installed at ELI-ALPS already in 2024 and is now already in use for analysing plasma samples of the H4H study from 1,000 patients across six consecutive visits [1]. With the successful commissioning of Infrasampler 3.0, the Hungarian laboratory is expected to increase the sensitivity and information content of the method, while at the same time improving the measurement throughput.

Compared to the previous instrument, the Infrasampler 3.0 system offers a twice as large simultaneous mid-infrared (MIR) spectral coverage over the important fingerprint region from 3 to 12 µm [2]. The technology is based on a pair of repetition-frequency-synchronized Cr:ZnS oscillators emitting single-cycle laser pulses centered at 2.2 µm wavelength with unprecedented carrier-envelope phase stability of 5.9 mrad [3]. By sending the fundamental pulses into a zinc germanium phosphide (ZGP) crystal, they are converted in a highly efficient (12.5 %) cascaded intra-pulse difference frequency generation process to the mid-infrared [4]. These broadband MIR pulses excite molecular samples and are detected through electro-optic sampling (EOS) in a GaSe crystal, where they are temporally overlapped with gate pulses derived from the second synchronized oscillator. The system employs modulation of the repetition-rate lock between the two oscillators to achieve scanning over the full mid-infrared electric-field waveforms at 4 kHz. Attosecond-precision reconstruction of the temporal axis is provided by electro-optic delay tracking (EODT) [5]. The high-speed instrument streams up to 15 GB of data for each 90-second-long measurement. Computer scientists of the FRIS team developed dedicated high-speed algorithms for automated processing and archiving of the measurement data in a home-developed database system.



Left: Home-built automated sample handling system with modulated sample exchange. Right: Microfluidics team presenting at the ATTOWORLD-alumni meeting (from left to right: Dr. Igor Kukhtevich, Akash Singh, Dr. Elisa Lambert, Amaj Chamankar). Images: FRIS-team

A major innovation in Infrasampler 3.0 is its custom-built sample handling system, developed by the group's microfluidics team. Equipped with a robotic arm that navigates and injects blood plasma into the sample cell from sample vials with high positional accuracy, the system ensures precise and contamination-free sample delivery. During data acquisition, sample and reference liquids are alternately injected into the measurement cuvette in a controlled sequence. This alternating injection scheme with modulation at Hertz rates, effectively compensates for slow fluctuations in the laser system and environmental drifts [6]. As a result, the system achieves superior baseline stability and allows for extended averaging times, which directly enhance the sensitivity and reproducibility of the measurements.

The development of the Infrasampler 3.0 was pursued by Dr. Philipp Steinleitner, Dr. Dionysios Potamianos and other members of the FRIS-team at the LMU laboratory in Garching. The fully operational laser system consists of several modules designed for optimum stability and performance, including the two Cr:ZnS lasers with synchronization, an air-tight mid-infrared-generation and electro-optic detection chamber, high-speed data acquisition with home-developed detector electronics, and the sample-handling system. The critical moment came, when the system filling a full optical table was disassembled carefully and prepared for transport to its new home at the ELI-ALPS in Szeged. After unpacking, the team could complete the installation of Infrasampler 3.0 in just one week, and within five days the team was able to reproduce all the most important signals from previous measurements in the LEX laboratory in Garching.

Looking ahead, the next phase of work will focus on improving user accessibility for upcoming clinical measurement campaigns and implementing advanced stability monitoring of the laser and detection systems. Once the stability characterization is complete, the team plans to repeat a series of reference measurements on commercially available substances, replicating the benchmark experiments carried out before shipment.

In parallel, development is already underway for a new generations of the Infrasamplers, exploring power amplification, multi-channel EOS detection, new approaches for delay calibration and dual-oscillator scanning and seamless extension of the spectral coverage to the single-THz regime.

FRIS-team while lifting one of the laser chamber up in LEX laboratory. From the left: Dr. Philipp Steinleitner, Aleksander Sebesta, Dominika Bondar. Image: FRIS-group

original publications:

[1] **octave-spanning mid-infrared electric field-resolved molecular fingerprinting of human blood plasma**
AUTHORS: A. Maity et al.
CONFERENCE PAPER: ***CLEO Europe 2025***

[2] **two-octave-spanning dual-oscillator field-resolved infrared spectrometer recording at kHz rates**
AUTHORS: D. Potamianos & P. Steinleitner et al.
CONFERENCE PAPER: ***CLEO Europe 2025***

[3] **ultra-CEP-stable single-cycle pulses at 2.2 µm**
AUTHORS: M. Kowalczyk, N. Nagl & P. Steinleitner et al.
JOURNAL: ***Optica* 10**, 801 (2023)

[4] **single-cycle infrared waveform control**
AUTHORS: M. Kowalczyk, N. Nagl & P. Steinleitner et al.
JOURNAL: ***Nature Photonics* 16**, 512 (2022)

[5] **dual-oscillator infrared electro-optic sampling with attosecond precision**
AUTHORS: A. Weigel & P. Jacob et al.
JOURNAL: ***Optica* 11**, 726 (2024)

[6] **field-resolved sample-modulation spectroscopy for mid-infrared molecular fingerprinting**
AUTHORS: W. Schweinberger et al.
CONFERENCE PAPER: ***CLEO Europe 2025***

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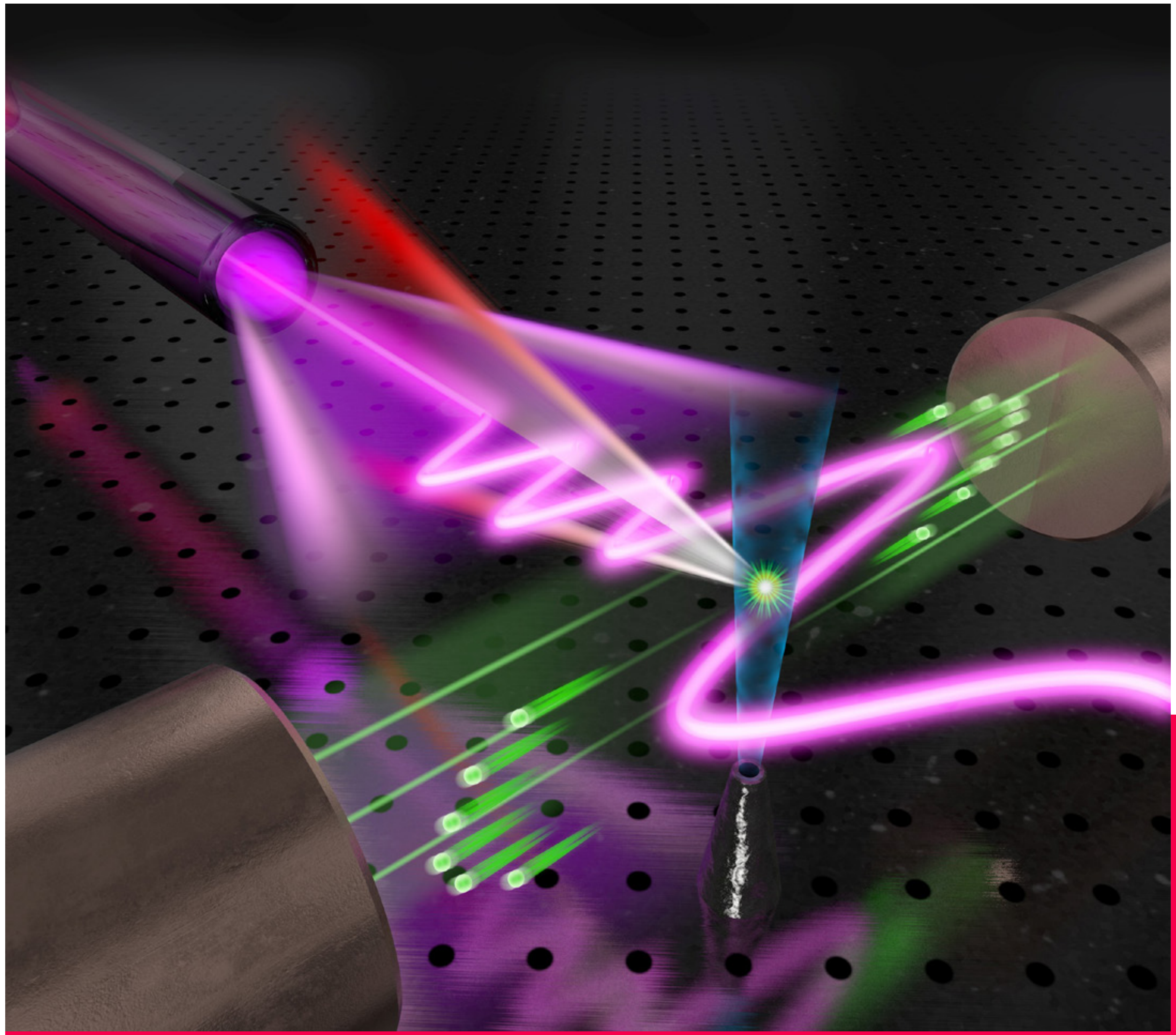
attoworld.de/fris

cracking the code of ionization

optical attosecond science

November 6, 2025 // apl. Prof. Dr. Vladislav Yakovlev

At **ATTOWORLD***, many of our most advanced experiments are built on an incredible ability: measuring the exact, ultrafast waveform of a light pulse. To reach the petahertz bandwidth, techniques for such 'optical-field-resolved' measurements often rely on a single, microscopic event: strong-field ionization. For decades, this event has held a stubborn theoretical puzzle. The optical attosecond science team is facing the challenges the puzzle offers and is working on some solutions.*



An artist's view of nonlinear photoconductive sampling driven by an attosecond soliton.
Image: Dr. Christian Hackenberger & Dennis J.K.H. Luck

The Problem: A Blurry 'Instant'

Here's the challenge: what exactly is the ionization rate? How many electrons are freed during each sub-femtosecond half-cycle of the field? For years, theory has been stuck. Because a strong laser field fundamentally blurs the line between a 'bound' and 'free' electron, defining an instantaneous rate of multiphoton ionization is a famously ambiguous problem. There are well-known analytical theories, but everyone who relied on these rates to interpret their measurements, had to use approximations that we knew weren't quite right. We decided to flip the problem. Instead of trying to calculate the ambiguous rate from first principles, what if we could retrieve it from unambiguous observables? We asked: "Can we find a single, universal formula that, when fed any laser pulse, can accurately predict the final, measurable ionization probability?"

Our Solution: The GASFIR 'Master Key'

In the framework of his doctoral research, Manoram Agarwal has developed such a tool, which we call the General Approximator for Strong-Field Ionization Rates, or GASFIR. Think of it as a 'master key' for ionization dynamics. We 'machine' this key by training it on a set of known, highly accurate ab initio calculations (the 'locks') for just a few specific laser pulses. By adjusting only a few parameters, GASFIR learns the essential, underlying physics of the interaction. Once trained, this 'master key' is incredibly powerful. It can now unlock the precise, time-resolved ionization dynamics for any pulse we give it.

What's Next: From Atoms to Electronics

Our simulations show that GASFIR successfully reconstructs complex quantum effects like channel closing in atoms. But the real excitement is just beginning. Our preliminary data shows that the GASFIR method works for solids, too. This gives us, for the first time, reliable photoinjection rates for semiconductors and dielectrics. With this tool, we can now study how various effects influence photoinjection dynamics, optimize future experiments to achieve a single photoinjection event per laser pulse, and push the frontiers of lightwave electronics.

original publication:

a general approximator for strong-field ionization rates
AUTHORS: Manoram Agarwal, Armin Scrinzi & Vladislav S. Yakovlev
MANUSCRIPT: ***https://doi.org/10.48550/arXiv.2507.03996***

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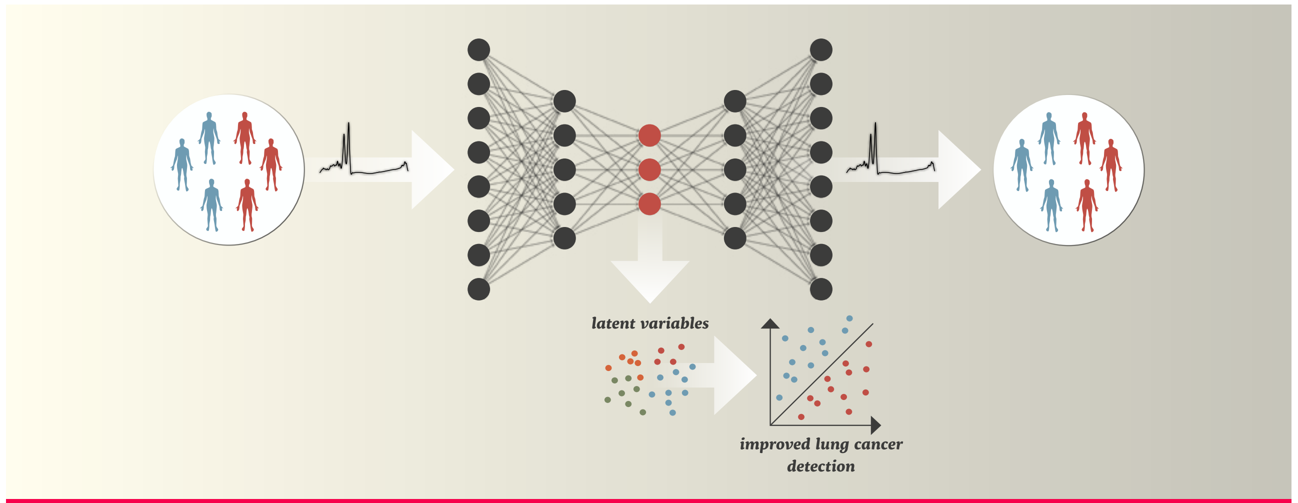
attoworld.de/atto-20

decoding the hidden data of human blood

November 3, 2025 // Dr. Kosmas Kepesidis

Every drop of blood is a data set – a complex pattern of molecules whispering information about the body's health state. In 2025, the Data Science team at ATTOWORLD revealed how advanced algorithms can turn these molecular signals into actionable biomedical insights, transforming spectroscopy into a powerful lens on human health. Dr. Kosmas Kepesidis reports on these newest results.



The data science team applied unsupervised deep learning to compress blood-based infrared spectra into a compact set of noise-reduced variables, revealing distinct disease-related features that can improve diagnostic accuracy.
Graphic: Dennis J.K.H. Luck

From Molecules to Data

Traditional diagnostic tests search for specific biomarkers – measurable molecules linked to a defined physiological condition. Yet biology rarely confines itself to such simplicity. Disease perturbs not one molecule but thousands, subtly reshaping the entire molecular landscape. Recognizing this, our approach treats the complete biochemical profile as an informative pattern, rather than isolating individual markers. Using infrared spectroscopy, we illuminate blood serum with infrared light or laser pulses, capturing a molecular fingerprint that encodes the chemical state of the sample. Each spectrum is a high-dimensional data vector – a compressed record of countless molecular vibrations and interactions.

The Data Science of Blood

Extracting meaning from these fingerprints requires powerful data analytics. Our team trained machine learning models to recognize patterns within this high-dimensional, noisy data. These models learn to distinguish subtle spectral variations that correspond to specific physiological states or diseases. What emerges is not a single biomarker but a dynamic pattern that changes as the disease progresses.

In our studies published in BMC Medicine and ACS Central Science, we demonstrated how such models can translate raw spectroscopic signals into biomedical incites. Further refinements, described in an article published in Analytical Chemistry, introduced robust data pipelines to correct for instrumental drift and device variability – ensuring that each signal retains its informational integrity. And in an article published in Journal of Biophotonics, we employed unsupervised deep learning to uncover low-dimensional representations of these infrared molecular fingerprints, revealing hidden structure in the data.

A Dialogue of Disciplines

Through the lens of data science, blood-based spectroscopy becomes a conversation between physics, chemistry, and medicine. The blood sample acts as a transmitter, its molecules vibrating and shifting in patterns that broadcast subtle signals of health or disease. The spectrometer receives these signals; the algorithm decodes them. At the heart of this process lies an information-theoretic insight: health is a state of ordered complexity, and disease a disruption in that informational order.

By listening carefully to the data embedded in the molecular vibrations of blood, we are beginning to translate the language of biology into the language of information. This shift points toward a future where diagnosis will not rely on a single chemical test, but on algorithms trained to interpret the multidimensional symphony of life itself.

original publications:

assessing lung cancer progression and survival with infrared spectroscopy of blood serum
AUTHORS: Kosmas V. Kepesidis et al.
JOURNAL: ***BMC Medicine* 23**, 101 (2025)

electric-field molecular fingerprinting to probe cancer
AUTHORS: Kosmas V. Kepesidis et al.
JOURNAL: ***ACS Central Science* 11**, 4 (2025)

bridging spectral gaps: cross-device model generalization in blood-based infrared spectroscopy
AUTHORS: Flora B. Nemeth et al.
JOURNAL: ***Analytical Chemistry* 97**, 19 (2025)

toward informative representations of blood-based infrared spectra via unsupervised deep learning
AUTHORS: Corinna Wegner et al.
JOURNAL: ***Journal of Biophotonics* 18**, 8 (2025)

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attoworld.de/data

from bits to blood tests

understanding how much a single sample can reveal

October 30, 2025 // Dr. Kosmas Kepesidis

How much can a single blood draw really tell us – not just about one disease, but about a person's overall health and biology? Today's laboratory tests can measure thousands of different molecules in the blood, from proteins and fats to subtle chemical 'fingerprints' captured by infrared light. These powerful tools promise earlier disease detection and more personalized health insights. Yet, there is still no simple way to compare how informative different tests are. Traditional measures – like how accurately a test detects a disease or how many molecules it measures – don't answer the deeper question: how much meaningful information about a person does each test truly contain, and how does that information build up when tests are repeated or combined?

Our team is developing a new mathematical framework to measure this idea using the language of information theory. Inspired by Claude Shannon, the founder of modern communication theory, we treat a blood test as if it were a communication channel – one that sends messages from your body to a computer through a noisy process of sampling, measurement, and analysis. Some of the biological 'message' is lost along the way, but some makes it through. The key question is: how much of that original message survives in the result? We express the answer in bits, the same unit used to measure information in digital communication.

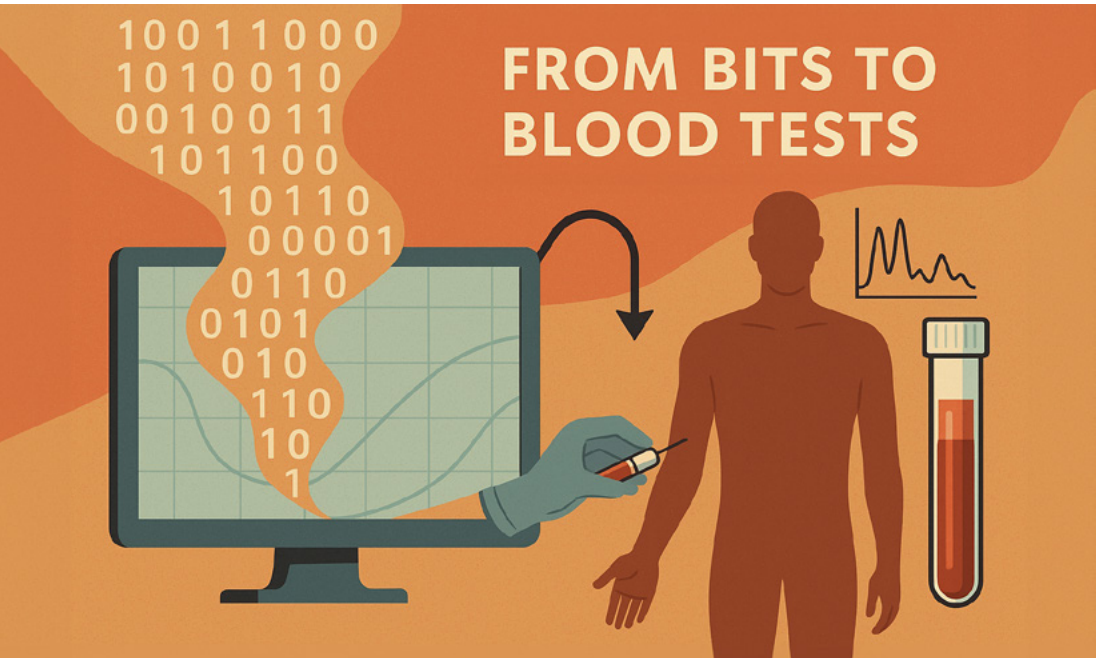

Image: Dr. Kosmas Kepesidis with 'Chat GPT'

Instead of trying to calculate the raw complexity of molecular data – which would be nearly impossible – we take a practical approach. We ask whether a computer model can tell which person a given blood sample came from. If it can reliably identify individuals among thousands, that means the system is transmitting real, person-specific information. From these identification tests, we can estimate how much information is contained in each sample, how much is lost as noise, and what the upper limit (or 'capacity') of the test might be. Together, these measures describe how much useful information a blood test delivers about an individual.

Our approach also works when we combine different types of tests, for example, comparing infrared molecular fingerprints with standard clinical laboratory results. By analyzing how these methods work alone and together, we can tell how much of the information they share, how much new information emerges when they are combined, and where information is being wasted. This helps us understand whether combining tests adds genuine value or simply repeats the same signals.

Because people are often tested multiple times, our framework also examines how information builds up over time. If the information increases steadily with each new visit, each measurement is adding new knowledge. If it levels off, the tests may be repeating what is already known. Expressing results in bits allows us to go one step further: we can compare information against cost, time, or sample volume, producing clear measures such as 'bits per euro' or 'bits per minute.' This links scientific insight directly to real-world efficiency.

We are now applying this framework to the Hungary for Health (H4H) study, which follows thousands of volunteers over multiple visits. Each participant provides blood samples that are analyzed using both infrared spectroscopy and standard lab tests. By comparing these two sources, we are quantifying how much information each provides, how it changes over time, and how much extra insight is gained by combining them. This analysis is ongoing, and current efforts are focused on refining the models and validating the results statistically.

Our long-term goal is to create a common currency of information for molecular medicine – a clear, quantitative way to describe what each type of test tells us about a person. By translating biological measurements into bits, we can fairly compare technologies, improve how we combine them, and make smarter choices about which tests are worth the time and resources.

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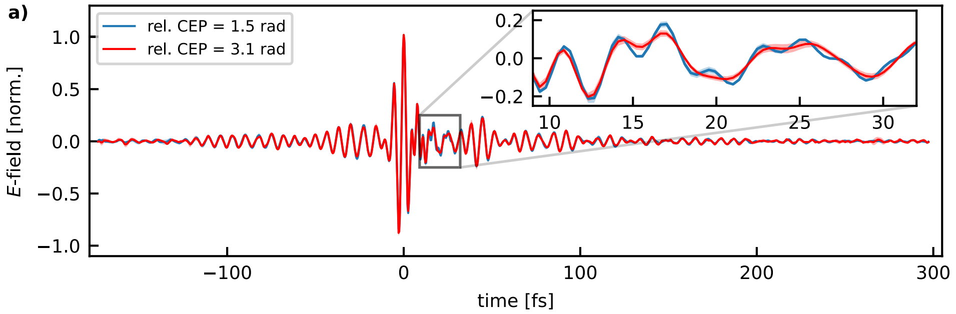
attoworld.de/data

a self-compressing broadening scheme for the HORUS laser

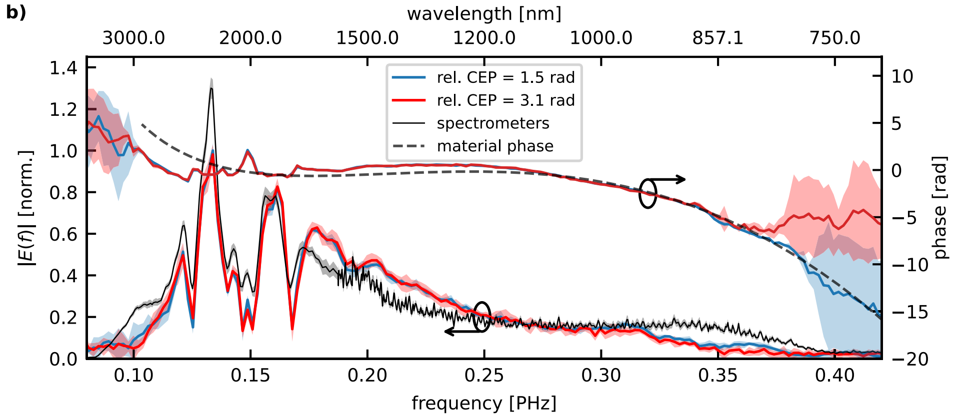
October 16, 2025 // Dr. Thomas Nubbemeyer

This year, the HORUS laser team in the attosecond spectroscopy 2.0 group of the **ATTOWORLD***-team has demonstrated a self-compressing broadening scheme for the HORUS laser system, a multi-millijoule high-power short-wave-IR light source delivering ultra-short, phase-stable laser pulses.*

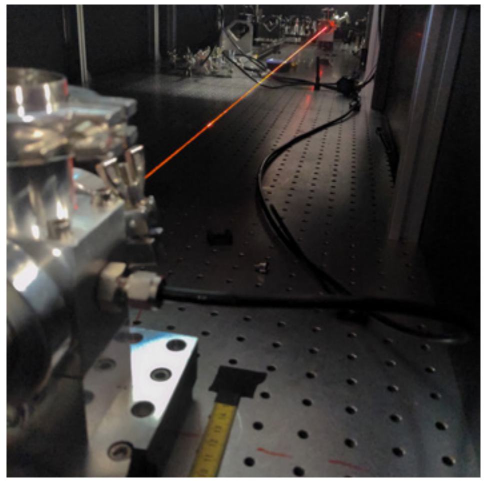
The HORUS laser system in operation. Photo: Thorsten Naeser



a) The measured electric field of the output pulse from the capillary fiber at different CEP values of the input pulse.



b) The reconstructed spectra from the field measurement along with a spectrum recorded with a regular spectrometer.
Figures: Johannes Blöchl



The stretched capillary fiber setup operating at full power
Image: Thomas Nubbemeyer

Efficient ways to compress laser pulses can greatly boost their peak power and make it possible to produce extremely short bursts of X-rays with a duration of attoseconds. However, it has been difficult to achieve high levels of compression with lasers that use longer wavelengths. In their recent work, the HORUS laser team demonstrated the compression of short-wave infrared laser pulses, centered at a wavelength of 2 micrometers, down to below 7 femtoseconds in duration, while maintaining a pulse energy of 2.4 millijoules and at an average output power of more than 23 W by using a stretched capillary fiber. Its parameters were adapted to the high average power of the HORUS laser system. Detailed measurements of the optical waveform show that the resulting light pulse contains only a single oscillation of the electric field. This system also achieves excellent stability with respect to the carrier envelope phase (CEP) and its average power. This makes it a powerful and reliable light source for advanced experiments in strong-field physics and the generation of attosecond X-ray pulses.

original publication:

multi-millijoule hollow-core fiber compression of short-wave infrared pulses to a single cycle
AUTHORS: Johannes Blöchl, Maximilian F. Kuthe, Hartmut Schröder, Abdallah M. Azzeer, Thomas Nubbemeyer & Matthias F. Kling
JOURNAL: ***Optics Express* 33**, 13, 28071 (2025)

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The 2025 Nobel Laureates in Physics: John Clarke, Michel H. Devoret, and John M. Martinis
Illustration: © Niklas Elmehed, Nobel Prize Outreach

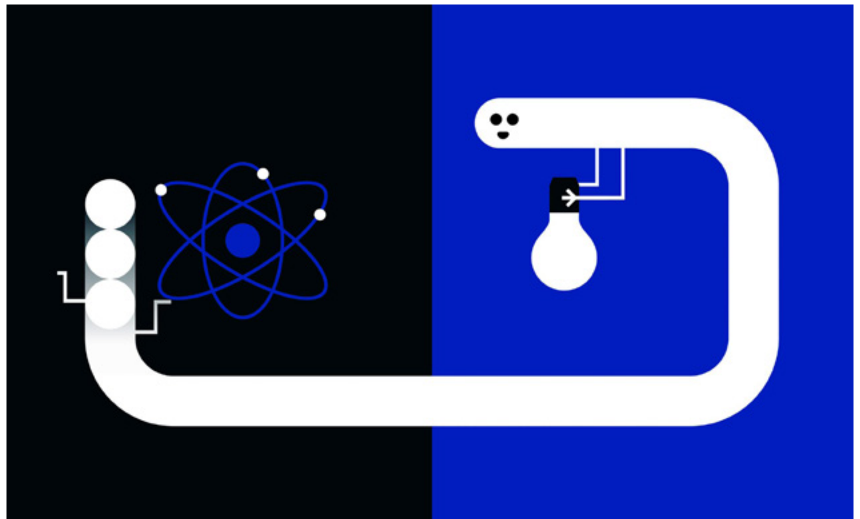
when quanta dance in circuits

October 3, 2025 // Dr. Veit Ziegelmaier

What do the mysterious laws of the quantum world have to do with the smartphone in our pocket? More than you might think. The three physicists John Clarke, Michel H. Devoret, and John M. Martinis were awarded the 2025 Nobel Prize in Physics because they demonstrated that the bizarre rules of the microworld apply not only to tiny particles but also to macroscopic electrical circuits. This discovery paves the way, in the long term, for a completely new generation of computers and sensors.

In the classical world, a ball can never pass through a wall, no matter how hard you throw it. The wall stands firm, and the ball bounces back. At the level of the smallest particles, however, the world works differently. Electrons and other quantum particles can sometimes simply pass through obstacles without destroying the barrier or being harmed themselves. Physicists call this phenomenon quantum tunneling.

The 2025 Nobel Prize in Physics was awarded "for the discovery of macroscopic quantum mechanical tunneling and energy quantization in an electric circuit."
Photo: © Johan Jarnestad, The Royal Swedish Academy of Sciences

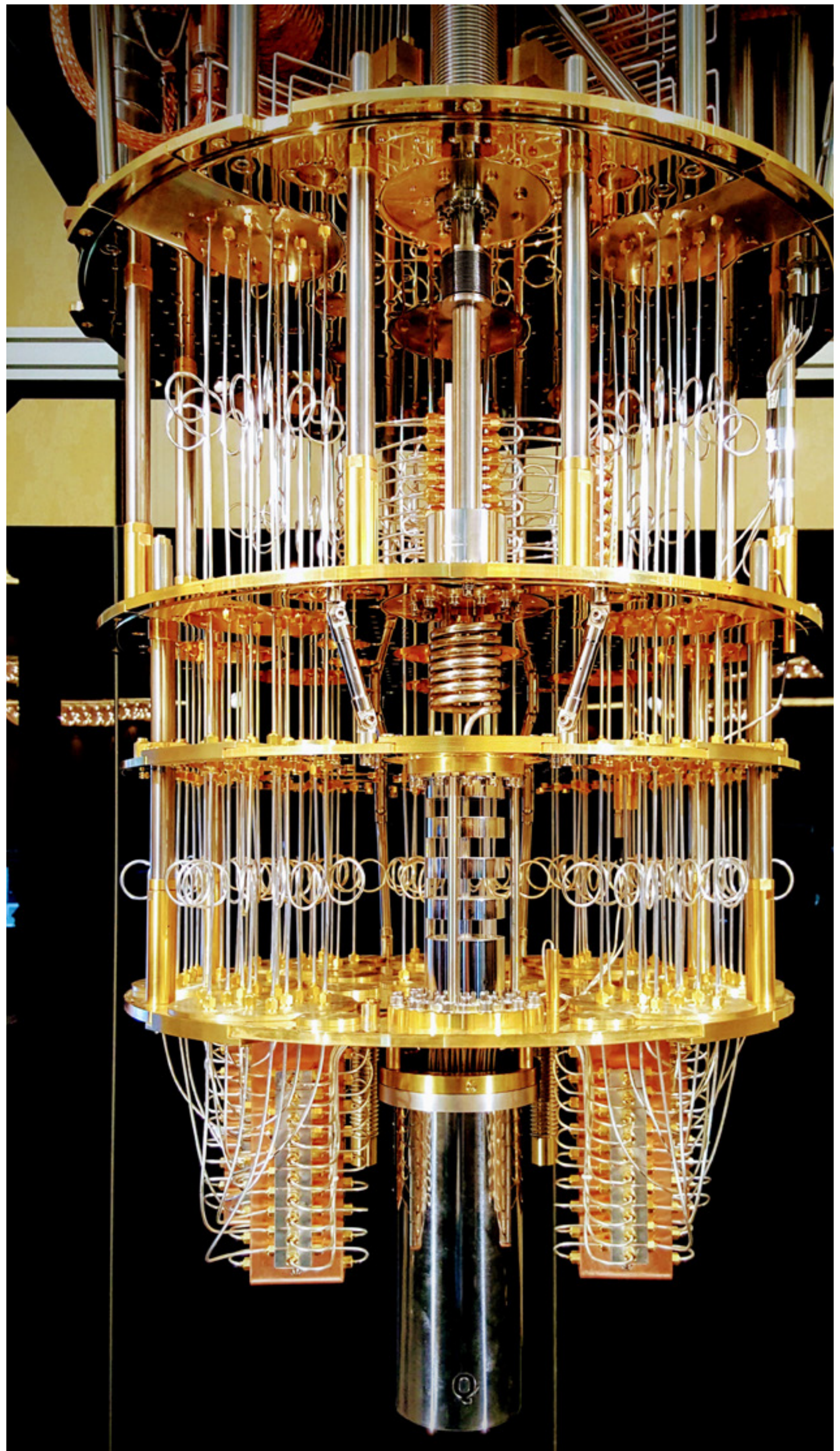


It was precisely this tunneling and the associated discrete energy states that Clarke, Devoret, and Martinis were able to observe in macroscopic electrical circuits in the 1980s and 1990s. They built tiny superconducting circuits, where current flows without loss, and discovered states that behave like atoms: they can jump, superpose, and tunnel.

In doing so, they literally brought the rules of the microworld from fundamental research into the world of electronics. Their experiments showed that even components visible to the naked eye can exhibit these quantum effects under certain conditions – if they are sufficiently well isolated and cooled to very low temperatures.

This insight laid the foundation for the later development of quantum computers and showed that macroscopic circuits can act as qubits. In such computers, information is no longer stored with classical bits, which can only take the states '0' or '1,' but with qubits, which can represent both states simultaneously. This superposition enables enormous computational power.

IBM's cryostat and 50-qubit quantum computer chip, exhibited at CES 2018.
Photo: © Lars Ploughman



The superconducting circuits studied by Clarke, Devoret, and Martinis now form the basis of many quantum computer architectures. Companies such as Google, IBM, and Rigetti rely on exactly this technology. John Martinis was even instrumental in building Google's quantum computer, which in 2019 demonstrated quantum supremacy for the first time – solving a computational task faster than any classical computer could.

The path from the smartphone in our pocket to the quantum computer is still long, but the connection is real. Without this fundamental research, there would be no semiconductors, no transistors, no modern computers, and thus no smartphones. And without pioneers like Clarke, Devoret, and Martinis, we would not know how to deliberately control and harness microscopic effects for practical use.

This year's Nobel laureates demonstrate that the boundary between fundamental research and practical application is often only a matter of time. What today may seem like a physical curiosity can tomorrow form the basis of new technologies – technologies that could transform our lives as profoundly as the first transistor or the first smartphone once did.

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

H4H program: from population averages to personal health models

November 27, 2025 // Dr. Domokos Gerő & Bernadett Szivák

Modern medicine largely relies on population-based reference ranges that take individual differences into account only to a limited extent. The H4H Program of the Center for Molecular Fingerprinting addresses exactly this issue by developing long-term, personal health models based on repeated blood analyses. Its goal is to identify early biological changes through 'virtual twins' long before diseases become apparent.

Dr. László Vastag, Director of CMF, took part in the Health Picnic roundtable discussion on 6 September 2025 at Bikás Park in Budapest. Photo: Center for Molecular Fingerprinting

World Diabetes Day health fair, 16 November 2025, Budapest, MoM Sport Event Venue. Photo: CMF

Today, most medical tests are interpreted the same way for everyone. You get a number, which is then checked against a population-based 'normal range.' This may be a useful benchmark, but it is a blunt tool and doesn't reflect your 'personal normal level.' Two healthy individuals can have very different 'normal' levels for the same blood marker. And for slow-developing diseases, a person's values might shift in a worrying direction long before they cross the population threshold. By the time that happens, the body may already be struggling, and extensive intervention may be required.

Data analysts Flóra Németh and Zita Zarándy gave a presentation highlighting how data science and laser physics are combined in H4H at Kutatók Éjszakája – Researchers' Night, 26 September 2025, Semmelweis University, Budapest. Photo: CMF

The Center for Molecular Fingerprinting (CMF) is working to change this by creating personalized health digital models using long-term blood sample data. By creating a **'virtual twin'** of each individual, any abnormalities could signal disease development at its earliest stage, long before symptoms appear. The work is being carried out through the center's **Health for Hungary – Hungary for Health (H4H)** Program.

People are not healthy in the same way

Even though human DNA is remarkably similar, slight differences accumulate into a wide variety of traits: how we look, our immune responses, hormone levels, and much more. Yet many standard medical tests are based on a single normal range derived from population averages. This is not because doctors and researchers ignore individuality, but because, until recently, medicine lacked sufficient long-term data to define what is normal for each person. Personalized interpretation needs long-term, repeated measurements from the same people, gathered under consistent conditions. Without that, doctors must rely on population evidence. The H4H program is designed to create that missing foundation.

The H4H Program and the idea of 'Virtual Twin'

H4H follows 15,000 healthy volunteers over 10 years, collecting and analyzing blood plasma samples at regular intervals to create a rich timeline of biological information. By tracking people repeatedly across time, researchers can map what their healthy aging looks like and build personal normal ranges: the unique patterns your body tends to follow when you're well. This is the concept of a 'virtual twin', a data-based model of your own healthy aging. Each new blood sample you give is compared against that personal model. If your real values begin to drift away from your virtual twin, this could be an early signal of disease development, well before symptoms appear.

This approach requires enormous datasets. H4H combines next-generation laser, mass spectrometry, and nuclear magnetic resonance-based technologies to extract the maximum information from blood plasma. With the help of artificial intelligence, the program aims to develop a personalized health screening tool to detect early molecular signs of illness before traditional markers become clearly abnormal.

Building a national effort

The program is still in its early stages; substantial real-world data and many years of observation are needed to build a robust model that will replace the traditional, population-based interpretation of measured health parameters. As a part of it, CMF is making various efforts to expand participation across Hungary and raise awareness of the H4H Program. In 2025, we connected numerous new health centers, including sites that had recently launched CT scanning. There have also been new referral options initiated from cardiovascular and lung screening programs. A new national recruitment campaign was also launched in November.

The H4H Program follows 15,000 healthy volunteers over 10 years, collecting and analyzing blood plasma samples at regular intervals to create a rich timeline of biological information. Photo: Thorsten Naeser

This work is complemented by public engagement. CMF's outreach includes marketing campaigns, online information, media interviews, and community health events. In 2025, CMF colleagues met potential volunteers at Hungary's first Health Picnic, the Researchers' Night, and at a World Diabetes Day health fair, answering questions face to face. These interactions help translate a complex research effort into something people can understand, trust, and feel part of.

Why this matters

H4H is a ten-year study, and that timescale reflects the kind of careful, patient science real breakthroughs often require. Its success will lead to the development of routine personal monitoring that detects disease earlier, allowing earlier intervention with gentler treatment, and makes prevention far more effective. In other words, H4H has the potential to shift healthcare from reacting to illness to preventing it – an advance that could reshape medicine, and the way health systems work, for decades to come.

Read more about Hungary for Health (H4H):

h4h.hu

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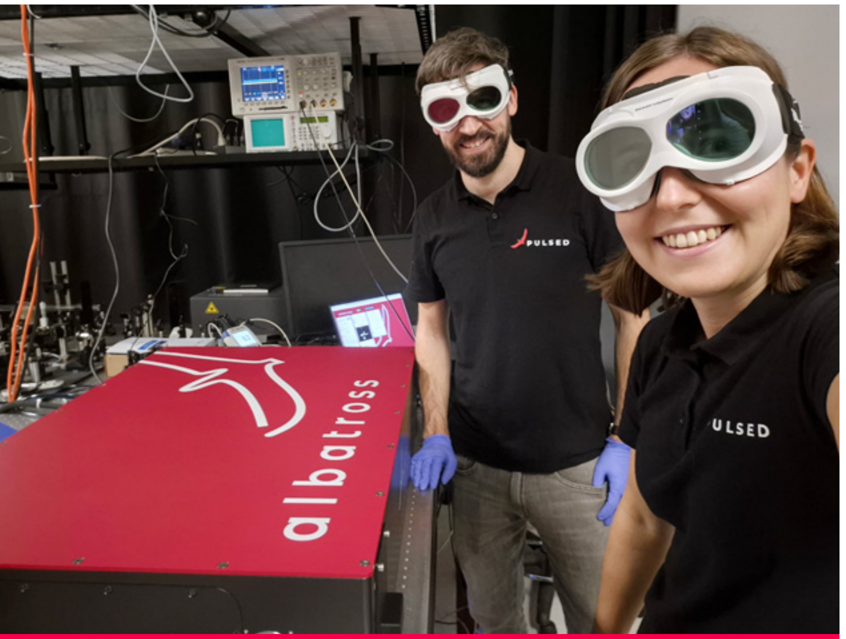
In 2022, PULSED was incorporated as an independent spin-off from the LMU Munich and the Max Planck Society. It makes phase-stable, ultrashort-pulse infrared lasers commercially available. These laser sources are highly attractive for a wide range of scientific applications, such as ultrafast nanoscopy, 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.

stepping beyond borders

October 23, 2025 // Dr. Nils-Holger Haag

The last three years have flown by. PULSED began as a small team opening ATTOWORLD's Cr:ZnS technology to other groups and quickly gained momentum. What started with the mission to support ATTOWORLD's vision has grown into a company whose impact now reaches far beyond its original scope. CEO Dr. Nils Haag reflects on the milestones and shares what lies ahead.

The past years have been packed with moments that felt anything but ordinary and more has happened than we thought could fit into such a short time. Today, twelve Albatross systems have been delivered and what excites us most is where they've gone: this year, PULSED technology stepped beyond Europe - reaching North America and Asia. That's not just a logistical milestone – it's the beginning of our journey into the international market.



Nathalie and Sebastian celebrating the successful first transatlantic flight of the 'albatross'. Photo: PULSED

Taking this step as a young company has been – and still is – a bit intimidating. Entering new markets, navigating unfamiliar regulations, and building trust across borders is no small task. But it's incredibly rewarding to see our work resonate internationally, far beyond our local beginnings at ATTOWORLD.

Since our last update a year ago, we've welcomed four new team members. Each brings fresh energy, unique perspectives, and valuable skills – they have already become an important part of our journey. A warm welcome to Philipp, Denis, Armin, and Dima!

PULSED geared up and ready to take on the next mission.
Photo: PULSED

With the support of our new colleagues, we're entering a new chapter. Building on our Albatross lasers, we're focusing on next generation IR-spectroscopy platforms. On one side, there's the highly promising WINGS Project, supported by the BMFTR and carried out in collaboration with LMU and the University of Regensburg. The project is approaching its halfway milestone, and the first results from our modular systems are encouraging – we're moving towards a flexible platform for field resolved IR and pump-probe spectroscopy.
In parallel, we're assembling a dedicated team to advance the dual oscillator Infrasampler technology. The first prototype will be ready next year, laying the groundwork for various collaborations and practical applications.

Compared to where we were last year, the company has changed in many ways – sometimes even we're surprised by how different things look now. But that's part of the journey: growing step by step, learning as we go, and staying open to new ideas. We're curious to see what the next twelve months will bring and how we'll continue to evolve together. Until then, we wish everyone a wonderful winter season and a good start into the new year!

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UltraFast Innovations GmbH

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.

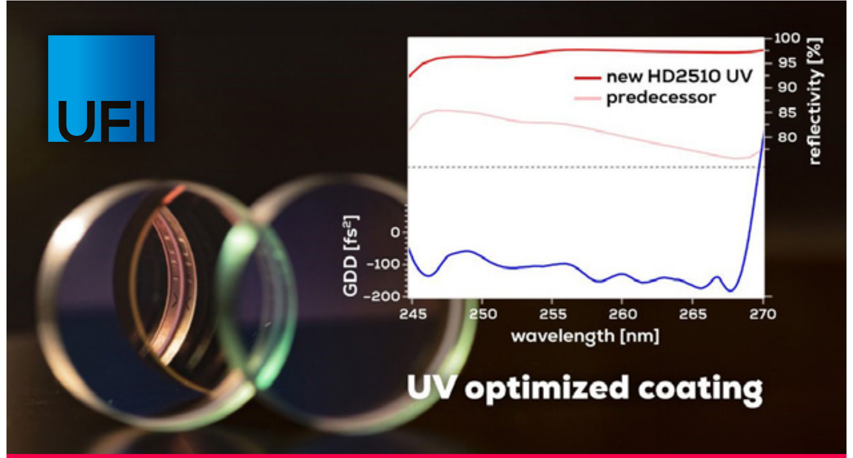
the ultrafast rhythm

November 19, 2025 // Dr. Veit Ziegelmaier & Dr. Verónica Oliver

When people think of light, brightness usually comes to mind. But for us at UltraFast Innovations GmbH (UFI®), it's all about shaping light with instruments and optical solutions for ultrashort laser pulses and experiments at the femto- and attosecond level. And just like every year, our curiosity drives us to be at the state-of-the-art in the field, bringing new solutions at this intersection of light and time.

Throughout the year, we had the opportunity to participate in eleven conferences across the globe. Some highlights included 'Photonics West' in San Francisco at the beginning of the year, 'Laser World of Photonics' in Munich, 'ATTO' in Lund, 'UFO' in the Azores, and ending the year at 'Frontiers in Optics' in Denver. Each stop gave us an opportunity to engage with scientists and engineers from around the world, gaining direct insights into the current research trends and sharing our latest developments.

The team during Laser World of Photonics in Munich.
Photo: Thorsten Naeser



Our new mirror design HD2510UV compared to its predecessor.
Image: Thorsten Naeser & Dennis J.K.H. Luck, UFI

Alongside these global appearances, we continued our efforts to push the boundaries of the field, introducing innovations in both our optics and devices departments.

The best examples in our coating department are the new UV dispersive mirrors. With an enhanced average reflectivity 20% greater than its predecessors and an exceptionally flat group delay dispersion, they make post-compression of the 3rd and 4th harmonics significantly more efficient.

In the devices department, we wanted to change the rules of the game. The pulse compression line, already established with our hollow-core fibres, is now completely flexible and tailored; with multipass cells, cascaded fibre systems, and all customisations to find the best solution to compress any laser system.

But UFI wouldn't be UFI if work didn't also leave room for small breaks. We make sure to have fun along the way. Alongside technical discussions and meetings, leisure activities found their place: a pickleball tournament – a mix of tennis and badminton – became a regular event at fairs and within the team, bringing together colleagues, partners, and visitors. Our charming mascot, Chirpy, accompanied us at conferences and events, spreading smiles wherever we went. Our team also reconnected during coffee and lunch breaks in our favourite new place – the rooftop.

Looking back at 2025, it's clear that our passion for innovation remains our greatest motivation. UFI empowers us to do what we love, which is pushing boundaries, and turning ideas into reality. Let's keep making a difference in the world of ultrafast science!

Chirpy, our mascot, announcing our pickleball challenge.
Image: Dennis J.K.H. Luck, UFI

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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, MQV, FOR 2783 & BMFTR and is visited by about 3000 interested students per year.

Atlantis at the MPQ

September 8, 2025 // Sofie Silbermann

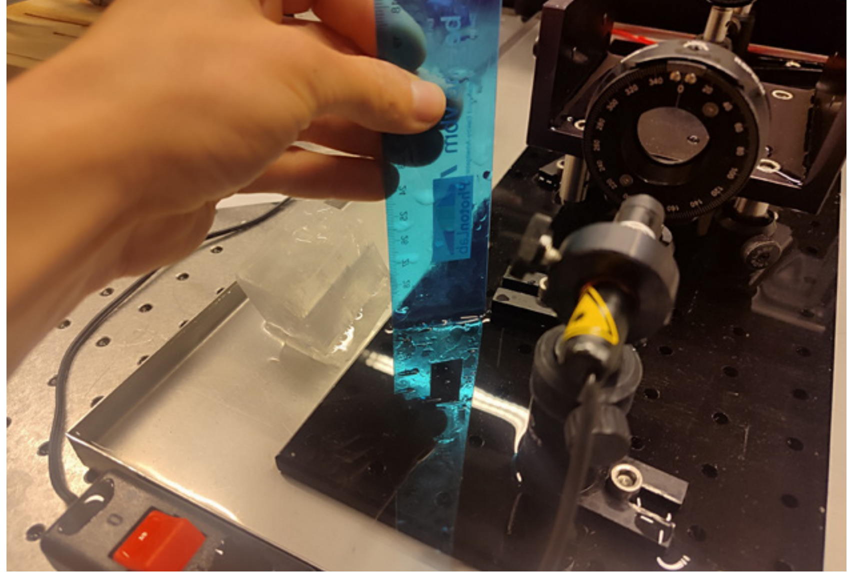
No one could have foreseen it. In July 2025, the worst-case scenario that all scientists in a laboratory fear, occurred at the PhotonLab student laboratory at the Max Planck Institute of Quantum Optics (MPQ). A water pipe burst. Forty cubic meters of cooling water poured from the cooling tank / reservoir onto all the experiments that had been lovingly designed over many years.

The alarm rang shrill through the Max Planck Institute of Quantum Optics in the middle of the night. The doorman discovered a small stream of water in the hallway and called the fire department. When he opened the door to the student laboratory, he was met by a torrent of water. The water mercilessly found its way into the basement through open channels, even though the fire department immediately pumped everything out.

The next morning, Dr. Moritz Dorband and Soňa Ertlová from PhotonLab inspected the total damage: all 25 experiments were destroyed. Anything that wasn't completely damaged had aged years overnight. The PhotonLab was literally under water: even plastic boxes had been penetrated by water, damaging sockets, laptops, and 3D printing projects. Anything that wasn't nailed down was washed away.

Sofie Silbermann adjusting the Helium-Neon-Laser.
Photo: Thorsten Naeser

Fortunately, the single-photon experiment in the basement was spared from disaster. The head of the student laboratory, Dr. Silke Stähler-Schöpf, was attending a conference in Canada at the time. That morning, she woke up to a picture of the water damage in the PhotonLab group chat. It showed Soňa and Moritz with the fire department in the background. But Soňa and Moritz had everything under control. They coordinated the rescue operation with their colleagues from MPQ.



PhotonLab under water.
Photo: Soňa Ertlová

Before anyone could even think about reopening, twenty-three school visits and about ten internships had to be canceled. Thanks to lively cooperation, the team found some alternative offers from colleagues on the campus. Seminar papers and internships were postponed until fall.

Fortunately, the move to Dr. Thomas Nubbemeyer's former attosecond research laboratory was already planned for 2025. The water damage accelerated the move. Due to its expanding size and the growing influx of school classes, the original premises of the PhotonLab have long since become insufficient. A larger laboratory will now lead to better teaching, a more pleasant learning atmosphere, more experiments, and a larger school class capacity.

But first, nothing could be touched for ten days until the assessor had recorded the damage. Then it was time to spend weeks writing lists. Every experiment had to be documented in detail for the insurance company.

Only then the new lab could be built up with complete experimental kits and some with individual components. New flyers, and stickers can now be printed, replacement parts organized, and the elements of the current laboratory that had not been affected by the water be reused. A room plan for the new laboratory was drawn up. It could now be freely designed. The team could now freely place tables, workbenches and desks and create barrier-free access. Two huge screens support the explanations of quantum mechanical phenomena, and school classes can spread out freely. Highlights and exhibits are slowly finding their place in the new laboratory. The Lab reopened its doors again exactly 3 months after the damage.

If you are curious about how the move went, you can watch a vlog series on Instagram (@photonlab_schuelerlabor).

Most importantly, we would like to thank everyone involved in making the move and the continued existence of the student laboratory possible. This includes the MPQ directors, especially Prof. Ferenc Krausz, who immediately pledged his support, and the institute management, but also the building services and technical teams. Thank you for the planning security and we are looking forward to many more wonderful years in the new PhotonLab student laboratory!

Part of the PhotonLab-team at work. From left: Dr. Moritz Dorband, Henry Hill & Soňa Ertlová. Photo: PhotonLab

can you extinguish fire with sound?

curious questions, great achievements – my GYPT experience

November 3, 2025 // Nikita Petrov & Dr. Veit Ziegelmaier

For many, this sounds like a crazy idea – but for me, Nikita Petrov, it was the beginning of an exciting year full of physics, curiosity, and challenging discoveries. In this report, I'll take you behind the scenes of the GYPT (German Young Physicists' Tournament) – from the first scientific question, through meticulous investigations and simulations, to heated discussions at regional, national, and international tournaments. It shows how a curious question can grow into a real research project that demands not only scientific knowledge, but also creativity, perseverance, and teamwork.

The winners of the gold medal at the 'unofficial' European Physics Championship for students (AYPT) in Austria: our author Nikita Petrov with Simon Hermes and Kurt Stiller (from left to right).
Photo: © DPG / Brandt 2025

The GYPT is a nationwide competition in which students independently investigate physical problems both experimentally and theoretically, and present their results in discussions with other participants. Each participant chooses one of 17 given physics problems, works on it for several months, and presents their solution in a twelve-minute talk. Afterwards comes an eight-minute 'opposition,' where other participants critically question the work and suggest improvements.

My chosen problem was 'Sound vs. Fire' – can small flames, such as candles or a Bunsen burner, be extinguished using sound waves, and how do the extinction process and various parameters relate to each other? After initial experiments with candles, I encountered issues with reproducibility and precise control of the flame parameters. Working with the Student Research Center Erlangen, I eventually used a precisely controllable gas flame. Theoretically, I drew on the acoustic wave equation and simulated the sound field in space under the supervision of the PhotonLab at the Max Planck Institute of Quantum Optics (MPQ). This allowed me to experimentally determine a critical sound pressure level required for extinguishing, based on the blow-off effect, in which the flame is displaced from its fuel source by acoustic pressure.

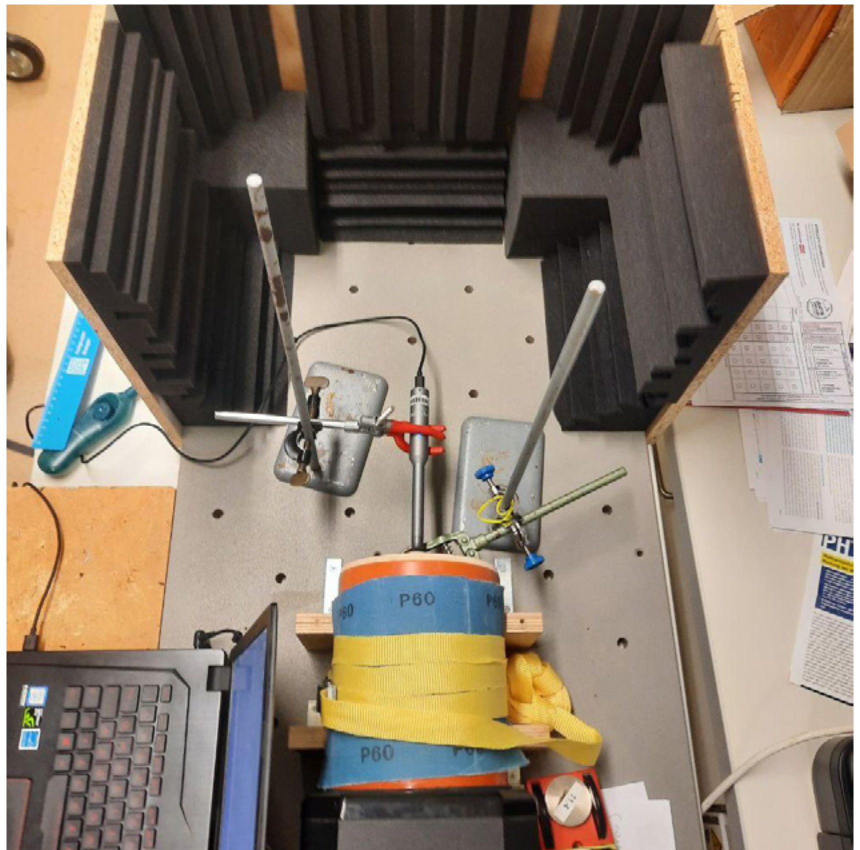
'Sound vs. Fire': Can small flames be extinguished using sound waves? This was the GYPT task that Nikita Petrov investigated theoretically and experimentally.
Photo: Nikita Petrov

The regional competition took place at the MPQ at the end of January. I placed third there and qualified for the national competition, where around 80 students from all over Germany competed for the title of German Champion. During the selection workshop in Ulm, the teams for the AYPT (Austrian Young Physicists' Tournament – the unofficial European Championship) and the IYPT (International Young Physicists' Tournament) were chosen. Together with two other participants from Berlin, I had the honor of representing Germany in Leoben, Austria. After four days of intense physics matches, we reached the finals against Sweden and Slovakia – and took first place!

Taking part in the GYPT became one of the highlights of my year: I deepened my understanding of various areas of physics, learned how to conduct scientific research, and made valuable connections with dedicated and inspiring fellow students. The atmosphere motivated me to keep going, explore new topics, and perhaps one day support younger participants in their own projects. I can wholeheartedly recommend the GYPT to anyone who enjoys physics and debating ideas – and who knows, maybe we'll meet at a physics match one day.

The Pulse magazine editorial team and all researchers at the MPQ warmly congratulate Nikita Petrov on this outstanding achievement!

A lot of tinkering and testing went into this: Here is the setup for the experiment with which Nikita Petrov later won the gold medal in Austria.
Photo: Nikita Petrov



"Have you heard of attoseconds?" — Crickets.
"Have you heard of femtoseconds?" — Still silence.
"Have you heard of seconds?" — "Yeees!"

PhotonLab back in the light

August 28, 2025 // Umai Galadriel Chibbaro Leiva

That's how Dr. Moritz Dorband, one of the PhotonLab's mentors, kicks off the first class in the newly reopened student lab. The laughter breaks the ice, and just like that, the adventure begins.

From Flood to Fresh Start

Almost three months after severe water damage forced it to close, the PhotonLab has reopened its doors, now larger, brighter, and buzzing with renewed energy. The new lab is located right next to the old one, in a room that used to host the AS Beamline. What once was roughly 70 square meters has now doubled to around 153 square meters. The experiment area itself grew from about 14 to 21.5 square meters, offering not only more space but also more possibilities.

"It's essentially a rebuild," explains Soňa Ertlová, a PhotonLab mentor. "We had to replace nearly all the old experiments, but we were not allowed to buy new ones on account of the insurance. The only 'new' ones had been in storage for a while because we did not have enough space".

Despite the challenges, morale stayed high thanks to the support from the institute, particularly from Ferenc Krausz and the technical teams. "We're incredibly thankful," the PhotonLab team adds. "Without the atto-technology group and our house technicians, reopening this quickly wouldn't have been possible."

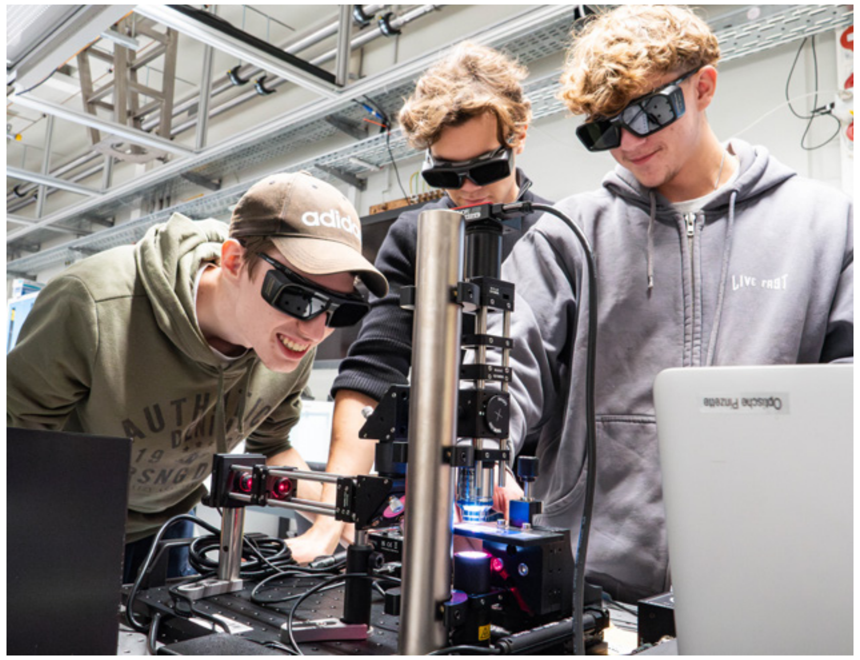
The First Class Returns

The first group to cross the heavy yellow lab door this past October was a 12th-grade class from the Karl-von-Closen Gymnasium in Eggenfelden. Inside, Moritz and Soňa welcomed them into the world of lasers, light, and ultrafast science. We followed them into this adventure. "What are attoseconds? What are lasers? Why did Ferenc Krausz win the Nobel Prize in 2023?" These were some of the questions thrown into the air before the hands-on work began. The room shifted quickly from polite curiosity to fascination. Especially when a spinning molecular model and a striking red laser beam took over everyone's attention.

Dr. Moritz Dorband gives an introduction to laser safety in the student laboratory.
Photo: Nina Beier

Before heading into the experiments though, safety comes first! Now with goggles on, students learned why laser light must never be looked at directly, and why even small, everyday lasers need to be handled carefully. Once everyone was set, students formed small groups and received blue tablets with instructions to each experiment. Every setup featured a small sign showing its difficulty, a simple but clever way to make sure there's something suitable for everyone. Naturally, Soňa and Moritz were there to answer any questions and help with the set ups. With more than 20 experiments, there was more than enough to do.

At last, the students scattered around the room to explore. The room filled with chatter, excitement and that distinctive buzz of people trying to figure out an experiment. And since this was the first class visiting the new lab, several new experiments were waiting to be tried. One station challenged students to build a spectrometer, using a prism and a few optical elements to split white light into its spectral colors. At another, a Pr:YLF laser setup allowed them to generate and tune laser light of different colors – red, green, or orange – by aligning three mirrors that each reflect different wavelengths. Precision is everything in the laser target alignment setup: by adjusting two mirrors, the students had to guide a laser beam so that it lands exactly on a small target. By the end, most groups had visited every station at least once, and the class left the lab with a mix of tiredness and awe.



Students at Karl-von-Closen Gymnasium in Eggenfelden catch 1-micrometer-sized Styrofoam beads with optical tweezers.
Photo: Nina Beier

Of course, there were plenty of other exciting new experiments to try, and you can see these yourself when you visit the new lab. For the PhotonLab team, though, the reopening was more than just new setups and space; it was a moment of relief and pride after months of hard work. "At first, I was very shocked to see the whole lab and all the experiments destroyed by all that water. But due to the support of so many people we soon knew that we will get the chance, to rebuild the lab," says Dr. Silke Stähler-Schöpf, manager of PhotonLab. "Now that all the work is done – a lot by Soňa and Moritz – we are very happy in our larger lab with all the new experiments around us. So finally, we have a happy end."

adventures in the quantum world

November 13, 2025 // Dr. Veit Ziegelmaier

When Alice stumbles into the Quantum Land for the first time and encounters Schrödinger's famous cat, a world unfolds for young listeners in which science and imagination merge. With 'Alice im Quantenland: Eine Katze namens Schrödinger' ('Alice in Quantumland: A Cat Called Schrödinger'), the pilot episode of the PhotonLab audio play series was released in June 2022. Aimed at children aged six to twelve and their parents, the project introduces the fascinating phenomena of quantum physics through entertaining stories. Since then, much has happened. Following the episodes 'Einstein und das Fußballmatch' ('Einstein and the Soccer Match') and 'Auf dem Quantenjahrmarkt' ('At the Quantum Fair'), the fourth episode, 'Die Zauberwürfel' ('The Magic Cubes'), is now being released. Available on all major streaming platforms, the series has already been streamed around 7,000 times and now takes our voice actors on live reading tours across Germany.

Our illustrator Andi Papelitzky gives the characters in our audio drama their distinctive appearance. Here is the motif for our current episode.
Illustration: Andi Papelitzky

The voices of Alice and Schrödinger: Sofie Silbermann & Dr. Veit Ziegelmaier at the live premiere of the new episode on November 8, 2025, in the LMU's Audimax.
Photo: Christoph Hohmann (MCQST

Our radio play enjoys prominent supporters: Harald Lesch has come out as a fan!
Photo: Dr. Silke-Stähler-Schöpf

After more than a decade of the PhotonLab at the Max Planck Institute of Quantum Optics (MPQ) establishing itself under the direction of Dr. Silke Stähler-Schöpf as a popular learning environment for middle and upper school classes, the idea emerged to make quantum physics accessible to primary school children as well. A series of audio plays inspired by the fantastical motifs of Alice in Wonderland provided the perfect framework. The unusual encounters in the story were not to stem from imagination alone, but to be inspired by real phenomena of the quantum world.

In the newest episode, Alice, Schrödinger, and Rabbit enter the legendary Fairy Tale Forest. There they meet Prof. Reinhold Bertlmann, who appears in the audio play with his real voice. He explains the phenomenon of quantum entanglement using pairs of socks in different colors that behave dependently on one another. But this phenomenon, described by Einstein as 'spukhafte Fernwirkung' ('spooky action at a distance'), can also lead to identical results under certain conditions. Alice and her friends experience this during a dice game with the Mad Hatter. And later, these very dice will help Alice out of a tight spot when the Queen of Quantum Land sets her sights on her because she has been far too curious. The story ultimately takes an unexpected turn, one that Alice is not entirely comfortable with.

The author of these lines, a humanities scholar with a musical background and a trained voice actor with experience in theatre from the **ATTOWORLD**-PR team, joined the project as narrator, producer, and scriptwriter.

'Welt der Quanten' (World of Quanta) is the name of our Alice song, which was also performed live in style in a cat costume. Photo: Thorsten Naeser

To date, four episodes have been released annually, accompanied by appearances at major science outreach events across Germany, including the Deutsches Museum, the Festival der Zukunft, the Münchner Wissenschaftstage, the 'Lange Nacht der Museen', the 'Türen auf mit der Maus-Tag', and the Tag der Quantenphysik at the main building of LMU Munich, where the newest episode premiered on 8 November 2025 in the Audimax. The project also features an original Alice song. Titled 'Welt der Quanten' ('World of Quanta'), it has been performed live at various events such as the 'Science Slam der Münchener Universitätsgesellschaft'.

As the audio play series reaches an ever-growing audience, more and more institutions across Germany have taken notice. This has led to a three-part feature at the Technoseum Mannheim, an appearance at the Maustag of the University of Würzburg, a reading at the Institute of Applied Physics at the University of Münster, and an invitation by the Deutsche Physikalische Gesellschaft to participate in next year's 'Highlights der Physik' in Jena.

How is an episode created?

At the beginning of each new episode is a creative exchange with our scientific advisory team. The scientific board consists of Dr. Nils Haag, Dr. Moritz Dorband, Dr. Silke Stähler-Schöpf, Dr. Linda Qerimi, and Dr. Tatjana Wilk, as well as Sofie Silbermann and myself as part of the production team. Together, we determine the thematic focus, prepare the selected quantum phenomena in an age-appropriate way, and develop the narrative structure of the episode. Based on this, I write the dialogue script, which is reviewed for scientific accuracy in close consultation with the advisory board and then approved.

In parallel, the cover artwork is created in collaboration with illustrator Andi Papelitzky. Once the script is complete, the roles are assigned and rehearsed. We then record a demo version, which serves as a guide for music and sound effects. As producer, I curate a suitable selection of audio material.

With all elements in place, studio production begins. Working with musician and sound engineer Lori Lorenzen, we record the final voice tracks, followed by mixing and mastering. Once complete, the episode returns to the stage: to live readings accompanied by social media reels and followed by a steadily growing community, including the presenters of the 'Sendung mit der Maus' ('The Show with the Mouse').

With each new episode, an audio play world grows that shows children and adults alike just how vivid and exciting quantum physics can be. Alice will continue guiding young listeners deeper into the wonders of the quantum world, and her journey is far from over.

Listen to all episodes of 'Alice' on Podigee.io:

Sofie Silbermann in the studio recording her character's lines.
Photo: Dr. Veit Ziegelmaer

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beyond the lab: uncovering hidden passions at ATTOWORLD

October 16, 2025 // Nina Beier

We know what they're like at work – but what about the after-hours? We caught up with five of our ATTOWORLD-team members to discover what they enjoy doing in their free time. You might be surprised at the diverse hobbies and passions of your colleagues.

Music and sport are two topics that shaped my life for a very long period of time. I started playing violin at 5 and saxophone at 7, and I still cherish playing music, especially with others. I'm currently playing in the AGV symphonic orchestra in Munich, where I've had the pleasure of performing in the 'Herkulessaal' in the residence of Munich twice already. The genre there is quite flexible and the diversity also draws out the different colors and harmonies of an orchestra.

Another passion of mine is dancing, which I started at the age of 15 during high school. As it brought me a lot of joy, I continued to visit different classes and then got invited to a tournament. I helped to build a competition focused training in my dancing school at Ulm and then trained for two years very extensively. This led to the opportunity to participate in international tournaments – a highlight of my dancing career so far. I am very grateful for all the connections and bonds I made through my passions and I will cherish the memories forever."

Benedict Röcken, PhD student, ATTO-group

For me, cycling is not just a sport, but a lifestyle. It's a way to continually challenge myself and to discover how far perseverance and effort can take me. Every ride is a reminder that dreams are achieved step by step or pedal by pedal. Cycling also allows me to live adventure in everyday life: whether it's a new route, an unexpected climb, or simply the feeling of freedom on two wheels."

Claudio Cavecchio, laser engineer, FRIS-group & CMF

When the weather is nice, I love to be outdoors. Climbing with my friends is my passion, for which I really like to drive to the Ith – a ridge in Germany's Central Uplands, which is close to my home town. When I can't find the time to take the long trip, I like to be creative either by finding a nice motive for my camera or just painting the motive myself. A big highlight for my photography was taking a picture of the comet C/2020 F3 (NEOWISE). I tend to paint more in winter, or when I feel stressed since it really helps me to clear my mind."

Max Koch, PhD student, FRIS-group

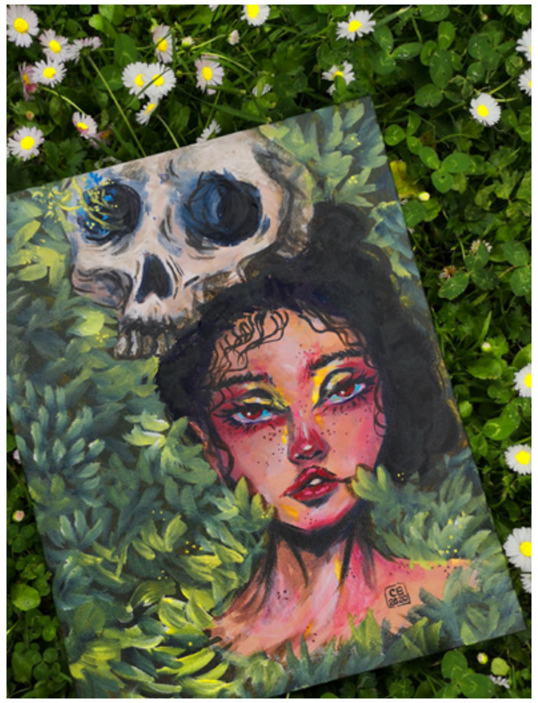
“I volunteer with the local fire department, not only as a firefighter and paramedic, but also as a so called CBRN (Chemical, Biological, Radiological, and Nuclear) advisor. In this role, I’m called out whenever an incident involves hazardous materials, chemical leaks, or – more rarely – biological risks and radioactivity. We respond with a specialized vehicle equipped with measuring instruments, sampling tools, and protective gear to assess and contain any danger.

In the photo, you can see me instructing a squad with heavy hazmat suits for a reconnaissance mission in an industrial building as part of a drill where we simulated a spill of an unknown chemical substance. My background as an experimental physicist really helps here – I work with measurement systems every day, and I find it fascinating to apply that knowledge in the field, for example when calculating the spread of toxic substances or estimating risks for the public and responders. Fortunately, such incidents are relatively rare, and I am called out for this role only about once a month.”

Maurice Zeuner, PhD student, HiFLAG-group

“I feel like I’ve been making art my whole life. I believe that we all start as artists. Being kids, drawing simply to express ourselves and have fun. I still approach art that way, picking up whatever medium helps me explore an idea or feeling. One experience very dear to me was my 2023 art expo, where I could talk to and see how people, strangers, connected with my work and interpreted it through their own lens (pun intended). Art lets me explore myself while also helping me form meaningful connections with others.”

Briana Cigan, Master student, ATTO-group



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

Dr. Weiwei Li

November 25, 2025 // field-resolved nano spectroscopy

“Petahertz strong-field light–matter interaction in nanomaterials”

Dr. Johannes Blöchl

November 17, 2025 // field-resolved nano spectroscopy

“Ultrafast pulse metrology”

Dr. Tarek Eissa

June 20, 2025 // broadband infrared diagnostics

“Infrared molecular fingerprinting to probe human health”

Photo: Nina Beier

the age of uncertainty

November 27, 2025 // Dr. Veit Ziegelmaier

In 2025, quantum mechanics celebrates its centenary – a revolution in thought that transformed not only physics but our entire understanding of reality. Its emergence marked the dawn of a new era, in which chance, uncertainty, and probability became the very foundations of existence. Dr. Veit Ziegelmaier gives a brief insight into the historical intertwining of modern physics and abstract art.

Before the quantum world revealed its depths, a subtler transformation had already begun. Every great revolution starts with a change in perspective – and for modern physics, that change came when space and time themselves ceased to be absolute. In 1905, Albert Einstein (1879—1955) challenged the notion of a fixed, universal framework with his special theory of relativity. Ten years later, he extended this vision in the general theory of relativity, describing gravity as the curvature of space-time. This replaced the classical idea of a rigid cosmos with a dynamic, relational understanding – a concept that profoundly influenced not only physics but also the philosophical and artistic currents of the era.

From the 1910s, and especially during the 1920s, painting, music, and philosophy began to break away from the certainties of representation, seeking new forms to express the invisible, the processual, and the energetic aspects of reality. The question of who painted the first abstract image remains a lively debate. For many years, Wassily Kandinsky (1866—1944) was considered the 'father of abstract painting.' A watercolor often cited as his first step toward abstraction is dated 1910, though it was likely painted in 1913 (Fig. 1).

Yet the female Swedish artist Hilma af Klint (1862—1944) had been creating abstract paintings as early as 1906—years before Kandinsky (Fig. 2). Her works remained unpublished during her lifetime because she believed the world was not ready for her spiritually inspired visual language. Only from the 1980s onwards was her oeuvre rediscovered and re-evaluated. Today, she is recognized as a pioneer of abstraction, whose vision of invisible forces and energetic structures anticipated the intellectual transformations of her time.

Wassily Kandinsky (1866—1944), 'Untitled' (First Abstract Watercolor), dated 1910, watercolor on paper, 49.6×64.8 cm, Musée National d'Art Moderne, Centre Pompidou, Paris

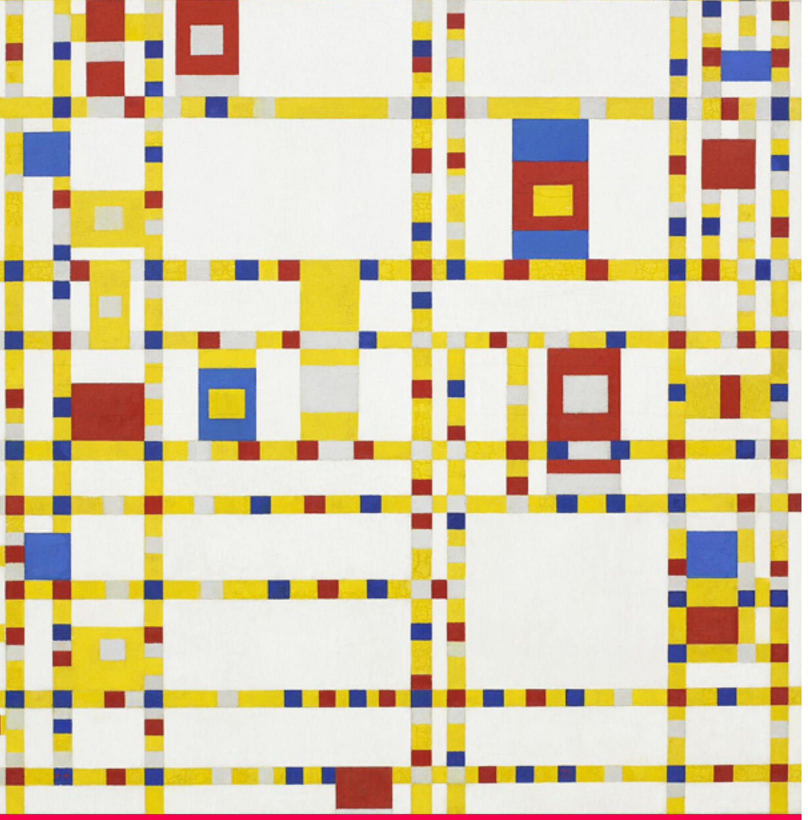
'Hilma af Klint' (1862—1944), Primordial Chaos, 1906, watercolor and ink on paper, courtesy of the Hilma af Klint Foundation.
Photo: Albin Dahlström,
© Moderna Museet Stockholm

A new perspective on matter emerged in 1913 with Niels Bohr's (1885—1962) atomic model. Electrons no longer move continuously but leap between discrete energy levels – a system of jumps and probabilities that replaced the classical worldview. Bohr's model combined order and discontinuity, structure and energy – concepts that would later resonate metaphorically in contemporary art.

In 1915, Kazimir Malevich (1878—1935) took a radical step in painting with his Black Square (Fig. 3). This minimalist work abandons representation entirely, reducing everything to the elemental components of color and form: a black square on a white background, seemingly floating in space. Rather than applying color uniformly, Malevich employed carefully placed brushstrokes to imbue the surface with subtle movement and vitality. Behind this apparently simple form lies a meticulously conceived concept, harmonizing idea, form, and materiality. The Black Square thus inaugurates a new era of abstraction, in which all figurative meaning is relinquished.

While Malevich distilled abstraction with his Black Square to its radical essence, other artists explored different ways of making the invisible visible. Kandinsky experimented with geometric shapes and colored planes that resonate like sound waves, reflecting the inner state of the viewer. Piet Mondrian (1872—1944) translated universal order into lines, rectangles, and primary colors, creating a balance of forces that can be understood metaphorically as an abstract, non-objective field of tensions

Kazimir Malevich (1878—1935), Black Square, 1915, oil on canvas, 79.5×79.5 cm, Tretyakov Gallery, Moscow



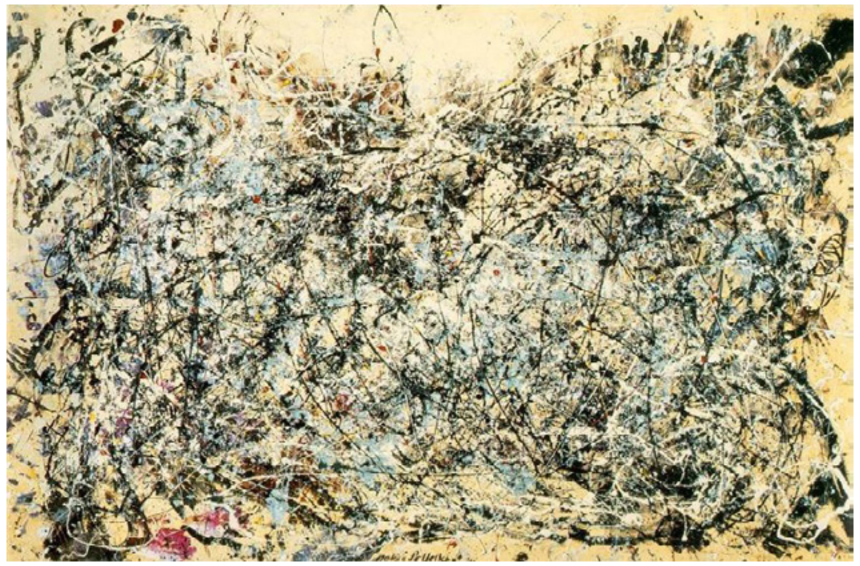
Piet Mondrian (1872—1944), Broadway Boogie Woogie, 1942/43, oil on canvas, 127 × 127 cm, Museum of Modern Art, New York

and relations, analogous to the conceptual space of modern physics. In his late works, such as Broadway Boogie Woogie (1942—43), this order acquires a new, rhythmic vitality: the grid seems to pulse with the energy and tempo of the metropolis (Fig. 4). The interplay of color and movement suggests, by analogy, a worldview in which reality is perceived not as fixed substance but as a dynamic field of relations, rhythms, and energies.

In the 1940s and 1950s, Jackson Pollock (1912—1956) let paint flow freely across the canvas, guided by movement, controlled chance, and bodily dynamics (Fig. 5). Pollock's drips and lines document the act of creation itself, offering a visual metaphor for the principles of energy, probability, and indeterminacy described by quantum physics. During the 1950s and 1960s, composers and conceptual artists such as John Cage (1912—1992) and Sol LeWitt (1928—2007) applied these principles to other realms: music, space, and ideas became fields of possibilities. Cage employed chance operations to produce unpredictable sounds, while LeWitt created works according to strictly defined concepts without personally controlling every step. Here, parallels to quantum physics emerge metaphorically: reality arises from events, not as a fixed state.

In both science and art, it becomes clear that the visible is merely an expression of the invisible. Abstraction allows us to perceive the world as a dynamic system of forces, relations, and possibilities. Artists and scientists alike strive to render the essence of reality perceptible – not through mere representation, but by conveying structures, processes, and vibrations.

Jackson Pollock (1912—1956), 'Number 1A', 1948, oil and enamel on canvas, 172.7 × 264.2 cm, Museum of Modern Art, New York.
Photo: © 2025 Pollock-Krasner Foundation, Artists Rights Society (ARS), New York



in neon light

when science becomes art

November 17, 2025 // Dr. Veit Ziegelmaier

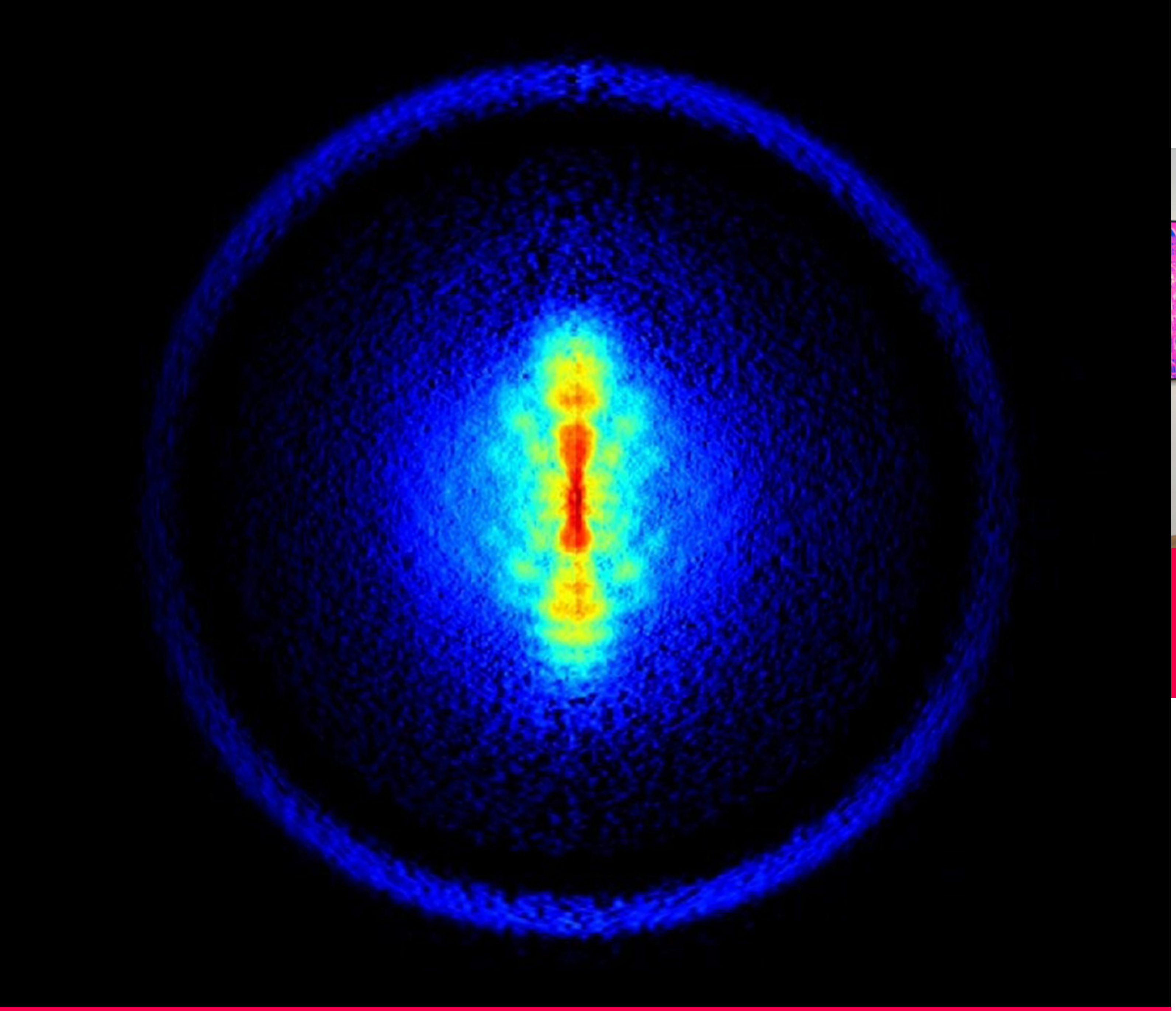
A brightly shimmering circle in intense shades of blue and violet. At its center lies a radiant core of red, yellow, and turquoise that dissolves outward into concentric zones of color. It almost resembles the iris of an unknown being, a colorful Rorschach test, or the trace of a tiny, barely comprehensible cosmic event. At first glance, the image appears to be an abstract composition of color and light. On closer inspection, however, it reveals a fascinating glimpse into the quantum world. The image was shown in the exhibition 'Civilization: The Way We Live Now' at the Kunsthalle Munich from April 11 to August 24, 2025. Titled 'Microcosm in Attosecond Flash,' it originated from the research group of Prof. Matthias Kling at the Max Planck Institute of Quantum Optics in Garching. It captures how an ultrashort attosecond pulse of light sets the electrons of a neon atom into motion, making a 'photographed' quantum structure visible.

The shimmering, pulsating appearance of the image invites viewers to look more closely and to sense the processes that underlie it. Attosecond laser pulses, lasting only an unimaginably brief billionth of a billionth of a second, can record the motion of electrons in atoms – motions that govern fundamental chemical reactions and physical processes at the heart of all life.

Science as visual discovery: Prof. Matthias Kling in the laboratory of the Max Planck Institute of Quantum Optics, where his research on attosecond laser pulses generates imaging data that possesses both scientific and aesthetic dimensions.
Photo: Thorsten Naeser

Science has long inspired art: from Leonardo da Vinci's anatomical studies to the mathematical perspectives of the Renaissance and the artists of the late nineteenth century who systematically explored light and color. Impressionists sought to capture fleeting atmospheres, while Pointillists analyzed light and color in tiny dots. With the onset of the twentieth century, this fascination with perception and with the invisible structures of nature broadened further, encouraged in part by the discoveries of quantum mechanics, which helped pave the way for abstract art.

Against this historical background, the exhibition 'Civilization: The Way We Live Now' turns its gaze to the present and views it through social, cultural, technological, and scientific perspectives. The exhibition explored the structures, dynamics, and contradictions of contemporary civilization.



Electron motion in a neon atom: The image ‘Microcosm in Attosecond Flash’ shows how an ultrashort attosecond pulse of light sets the electrons of a neon atom into motion, revealing a photographed” quantum structure.
Image: Prof. Matthias Kling / field-resolved nano spectroscopy

Over one hundred international artists – from established figures such as Edward Burtynsky, Candida Höfer, and Thomas Struth to younger artistic positions – presented a panorama of human societies, spanning consumption and mobility, urbanization and digitalization, culture, work, leisure, and developments in science and technology. Visitors were invited to ask their own questions: What kind of civilization are we building? What traces do we leave on our planet?

Within this broad panorama, Kling’s scientifically generated image stood out as a contribution shaped by a completely different context of creation, enriching the exhibition’s aesthetic diversity with a scientific perspective.

Kling, now the scientific director of the ‘Linac Coherent Light Source (LCLS)’ free-electron laser at ‘SLAC National Accelerator Laboratory’ in California, has worked for many years in the field of attosecond physics.

At the exhibition ‘Civilization: The Way We Live Now’: Visitors view the image ‘Microcosm in Attosecond Flash’, which introduces a scientific perspective on the quantum world into the broader thematic context of the exhibition.
Photo: Thorsten Naeser

At the chair of Prof. Ferenc Krausz, the pioneer of attosecond research and recipient of the 2023 Nobel Prize in Physics, Kling developed methods to visualize ultrafast, light-induced processes in molecules and nanostructures. In doing so, he contributed significantly to the emergence of attosecond nanophotonics, a field that continues to expand the boundaries of ultrafast science.

Within the exhibition, the image ‘Microcosm in Attosecond Flash’ assumed a distinctive role. It opened a window to quantum processes that remain hidden in everyday life and linked the microscopic dimension of physics with the larger story of human civilization. From the fleeting attosecond to the vast timescales of societal development, a poetic bridge emerges between science and culture, a moment in which the imperceptible becomes tangible.

The exhibition was not conceived as a rigid thematic sequence but followed an open structure of loosely connected juxtapositions that continually offered new vantage points. Visitors were invited to trace connections and reflect on the relationship between everyday life, technology, nature, and science. Taken together, the works on display revealed how the social, cultural, technological, and scientific dimensions of modern life are intertwined, each offering its own way of approaching and understanding the essence of our world.

Further information on the exhibition ‘Civilization: The Way We Live Now’ can be found here:

The dream of flying as an achievement of civilization: The artwork used for the exhibition poster at Kunsthalle Munich shows an aerial view of an airport, foregrounding global mobility and large-scale infrastructure as central aspects of contemporary civilization.
Image: Jeffrey Milstein, Newark 8 Terminal B, Newark, NJ, 2016, aus der Serie Flughäfen, © Jeffrey Milstein

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.

photonworld

an ark for the universe

August 28, 2025 // Thorsten Naeser

The vastness of the universe seems insurmountable to us humans. Even the nearest star system, Alpha Centauri, is 4.37 light-years away. With our current technology, the flight there would take around 6,300 years. How can we still manage to penetrate the depths of the cosmos? The solution could be generation starships. Such ships would have to function like a self-sufficient village – with births, deaths, and the passing on of knowledge.

The Initiative for Interstellar Studies has launched a design and concept competition on how generation starships could function. Under the name ‘Hyperion,’ teams from around the world developed ideas for space shuttles that would travel through space with around 1,000 people on board for at least 250 years to discover new, habitable worlds. The ships must have enough space to live, work, reproduce, and exist together as a society. This places high demands on architecture, food supply, air supply, wastewater recycling, and educational and cultural facilities.

Above all, it is important to maintain gravity throughout the entire flight. Gravity, as we know it on Earth, prevents muscle loss, bone loss, and vision problems. In order to artificially create these Earth-like conditions, parts of the ships must rotate constantly.

Like a steel village in space: The winning design, ‘Chrysalis,’ is based on a modular construction system.
Image: Chrysalis

This is how visionaries imagine clothing aboard the inter-generational spaceship. Image: HELIOS ARK

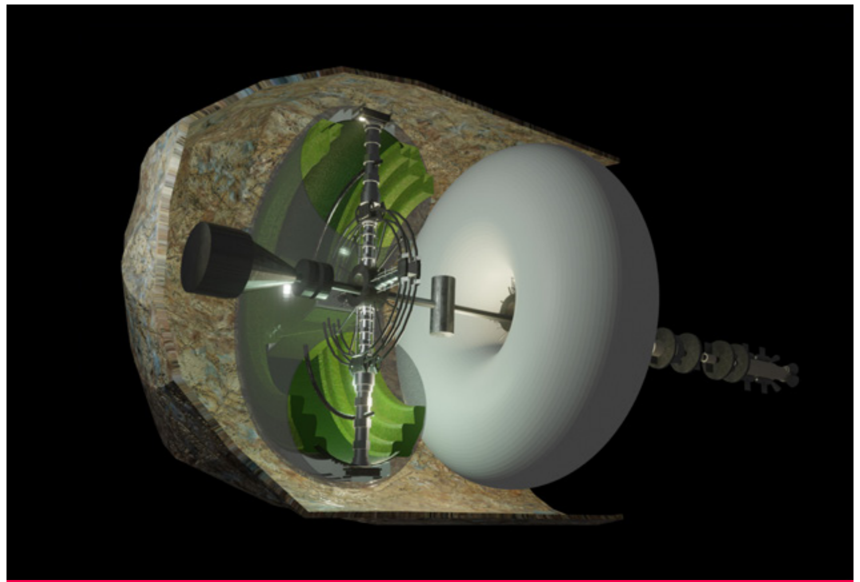
The teams spent months working on their detailed proposals. The organizers of the initiative presented the best ideas to the public in late summer: The winning team, ‘Chrysalis,’ impressed the jury with a spacecraft made of modules. It resembles a flying construction kit in space. Sleeping quarters, plant areas, technical rooms: Everything is separate but intelligently connected. A system that functions like a state-of-the-art village in space.

Second place went to ‘WFP Extreme.’ The visionaries focused on the socio-cultural design of life on board, with concepts for functional clothing in the spacecraft, but also for rooms for leisure and prayer.

> **“Hyperion was more than a design competition. It was about the question: Will we ever be able to travel to distant stars, and how would society develop there?”**
>
> Dr. Andreas Hein
>
> ***Hyperion director and member of the Space Systems Engineering Research Group at the University of Luxembourg***

Third place went to ‘Systema Stellare Proximum.’ The team focused on coexistence. Above all, there should be sufficient space on board the spacecraft for leisure activities and relaxation.

The best concepts will now be presented as thought models at space travel and science conferences. The ideas will then be used to create a realistic design for a generation spaceship. It could become the ark that helps us embark on a great voyage of discovery in the distant future. In a distant future, when life on Earth reaches its limits.



The team ‘Systema Stellare Proximum’ focused on the problem of coexistence.
Image: Systema Stellare Proximum

projecthyperion.org

portraits of the stars

October 2, 2025 // Thorsten Naeser

Photographing the Milky Way from space is something only a few people have managed to do. Astronaut Don Pettit is one of the chosen few. He photographed the stars from the International Space Station (ISS) and won the title 'Milky Way Photographer of the Year 2025.' This iconic view of our galaxy is the first image from the universe to be included in the Milky Way photo collection of the travel photo blog 'Capture the Atlas.'

The '**Milky Way Photographer of the Year 2025**' competition received over 6,000 entries. It includes images from photographers in 16 different countries, taken at 25 locations on Earth and beyond, including Chile, the United States, Greece, Switzerland, Guatemala, Australia, New Zealand, Taiwan, Argentina, Yemen, Chad, India, France, Namibia, Spain, and Portugal.

I float in the Cupola, looking out the seven windows composing this faceted transparent jewel. While my mind is submerged in contemplation, my eyes gorge on the dim reflections from a nighttime Earth. There are over eight billion people that call this planet home. There are seven of us that can say the same for Space Station. What a privilege it is to be here. I used an orbital star tracker to take out the star streak motion from orbit.
Photo: 'One in a Billion' – Don Pettit

Photo: ‘The Wave”’– Luis Cajete

The selection of the best photos, which can be viewed on the travel blog's homepage, includes not only classic locations for astrophotography, but also remote landscapes – from the deserts of Chad and the peaks of the Andes to the surreal landscape of Socotra Island and the pristine skies of New Zealand and Namibia. The posts show celestial events such as a comet, a meteor shower, and a lunar eclipse, captured under the glow of the Milky Way.

A little tip: the Milky Way photo season usually lasts from February to October in the northern hemisphere and from January to November in the southern hemisphere, with May and June offering the longest visibility. The best pictures are taken when the sky is dark, far away from light pollution, often at high altitudes or in remote corners of the world.

Photo: 'Cosmic Fire' – Sergio Montúfar

Photo: 'Double Milky Way Arch Over Matterhorn' – Angel Fux

capturetheatlas.com

mirror cleaning XXL

september 30, 2025 // Thorsten Naeser

Handy looks different. Perhaps astrophysicists envy laser physicists a little. At least when it comes to cleaning mirrors, that could well be the case. Because what laser physicists have to deal with on a much smaller scale, astrophysicists have to do on an XXL scale.

Here we see employees of the European Southern Observatory (ESO) removing an old aluminum coating from the main mirror of the 3.6-meter telescope at the La Silla Observatory in Chile. This is a necessary step before applying a new coating. The old layer is washed off by applying chemicals. Everything is then rinsed off the surface with demineralized water.

The mirror blank is then placed in a recoating chamber. There, aluminum is vaporized and applied to the mirror blank in a layer thinner than the width of a human hair! If this layer were thicker, its surface would be uneven. The mirror would not reflect enough light, resulting in the loss of valuable data.

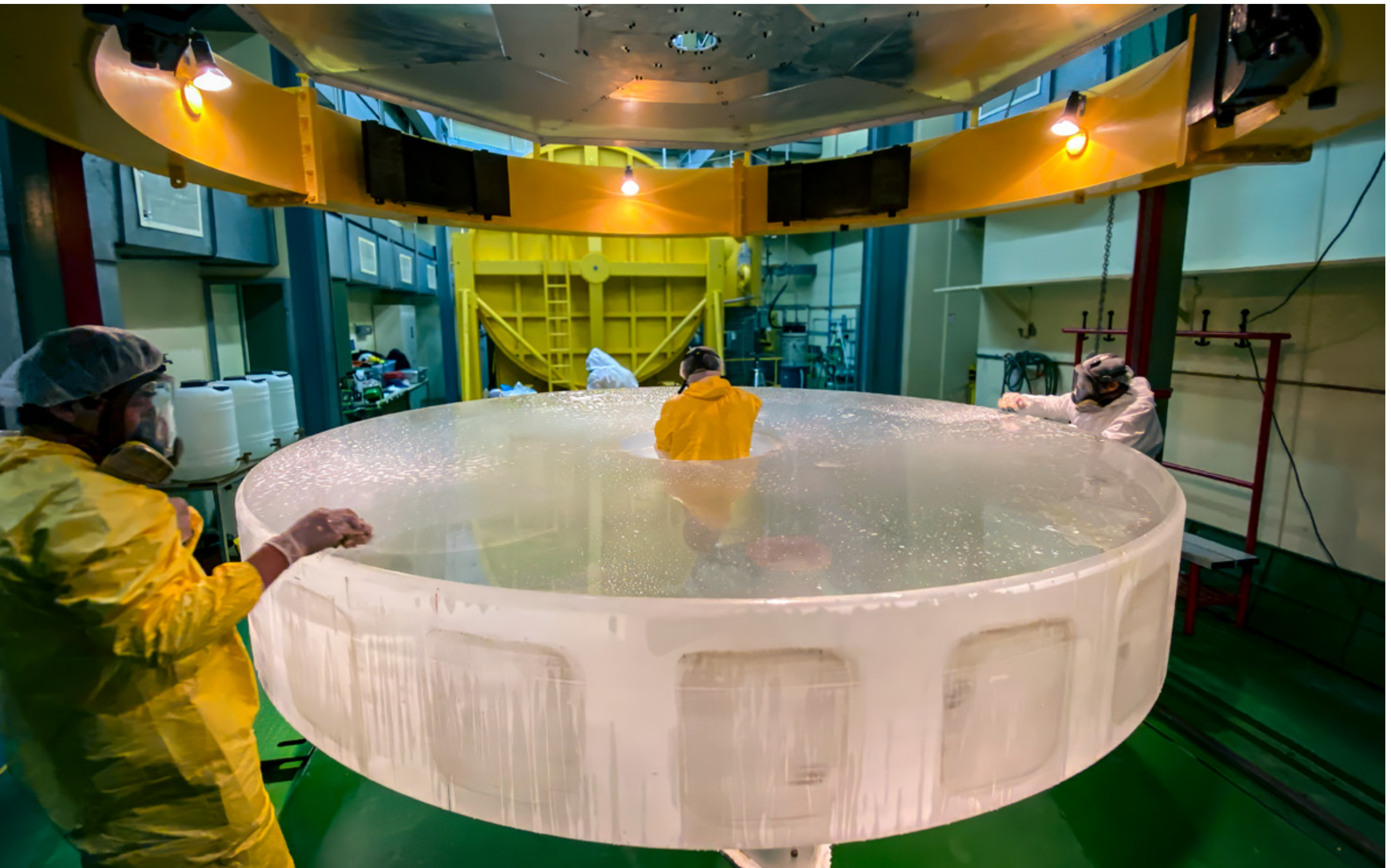


Photo: A. Silber, ESO

Photo: Andrew McCarthy

flying in front of the sun

December 8, 2025 // Thorsten Naeser

You've probably never seen this before. A man flying freely in front of the sun. The sun's swirling, glowing hot structures can be seen on the celestial body. It looks as if the tiny human being is flying right past the burning surface of the sun.

Andrew McCarthy took the picture in the Arizona desert while skydiver Gabriel Brown jumped from a small propeller-driven plane at an altitude of about 1,070 meters, about 2,440 meters away from McCarthy's camera. According to McCarthy, the shot, titled 'The Fall of Icarus,' required an 'absolutely absurd' amount of planning. The effort was worth it – it is likely the first photo of its kind. McCarthy combined the image with a Lunt 60mm H-alpha telescope and captured it with an ASI 1600-MM camera. An additional H-alpha filter allowed only a narrow reddish light frequency to pass through, which hydrogen emits when it loses energy and which makes the sunspots, several tens of thousands of kilometers in size, visible in the image.

The great distance between the telescope and the skydiver ensured sufficient depth of field, so that both the jumper and the sun, 150 million kilometers away, were sharply focused.

Prints of the photograph are available at cosmicbackground.io starting at $90.

cosmicbackground.io

the intelligent power of water

October 30, 2025 // Thorsten Naeser

Life began in water. Modern science and indigenous cultures agree on this. The Guna-Dule people of Panama and Colombia, for example, refer to the ocean as the mother's amniotic fluid, which carries the essence of previous generations. When the sea is damaged, they say, it is as if the womb has been wounded. For billions of years, the water of the oceans has been the medium of creation. It orchestrates our climate, shapes landscapes, and is responsible for the survival of humanity. Water shapes our past and our future. Julia Watson connects these themes in her book 'Lo—TEK WATER'. She breaks down the separation between technology and ecology, between traditional wisdom and digital innovation.

The book 'Lo—TEK WATER' is based on the knowledge of a lot of people who are directly involved in the topic. Most of the chapters were written together with Indigenous knowledge keepers. One of them is Joachim Cabral. He is the coauthor of the chapter on the Mithache Agor Salt Pans in India. Cabral was born in Mercês, Goa. He is a man who has devoted his life to water management and salt pan cultivation. Cabral works on the salt pans in Ribandar along the Mandovi River, in a region known for its unique environmental conditions ideal for salt production. With over 30 years of experience in the salt fields, Cabral has become a master of his craft and is widely respected in his community for his expertise.

Photo: Akhil Kulkarni

Along the southern coast of India, in a low-lying tidal basin known as 'the rice bowl of Kerala,' palm-fringed islands lie in a complex network of canals surrounded by vast open waters. This water-rich region lies two meters below sea level. Kuttanad is the only place in the country where rice cultivation is practiced below sea level. The early indigenous Malayalis developed artificial landforms called Kayalnilam to reclaim land from the sea. The system still functions smoothly today.

Often referred to as the 'Holland of the East,' the Kayalnilam resemble the Dutch polder landscape, where a polder or pond is created below sea level and protected by a raised barrier, a dike. Unlike in the Netherlands, however, the dikes in Kuttanad are built from local organic materials and are used to produce a range of foodstuffs. They are designed to adapt to fluctuating salt levels, prepare for climate extremes, adapt to them, and recover from them.

There are countless examples like this around the world. Traditional hydraulic engineering techniques for food cultivation or land reclamation are still in use today. In the best cases, they are supplemented by modern methods. Julia Watson presents these methods in her book 'Lo—TEK WATER'. The activist runs a landscape and urban design office that specializes in renaturation. Her book brings together impressive examples of traditional and indigenous water technologies – from floating farms and tidal fishing to groundwater recharge systems. Watson shows how such systems are by no means outdated relics of a bygone era, but rather offer forward-looking solutions to the challenges of our time, especially with regard to climate, water scarcity, and urban resilience.

Finally, the author draws parallels to the present day and presents contemporary water projects. In doing so, she ventures to bridge the gap between technology and ecology, between traditional wisdom and digital innovation. She advocates a technological renaissance that redefines water as an intelligent force with which resilient cities and landscapes can be designed.

Towards the end of the book, Watson reflects on how knowledge of traditional hydraulic engineering techniques could be incorporated into modern forms of settlement. "Beyond theory and utopias lies the call to action to redesign, regenerate, and rethink living space through the ancestral intelligence that guided Lo—TEK," she writes.

'Lo—TEK WATER' is a book that requires careful study. The design is impressive, and the content offers insightful perspectives on the challenges facing environmental science today. Anyone interested in sustainable construction, water infrastructure, and the connection between indigenous wisdom and contemporary planning will find this book a treasure trove of information.

taschen.com

Lo–TEK. Water. A Field Guide for TEKnology.
Julia Watson, Lina Müller, Piera Wolf & Stephanie Specht
TASCHEN Verlag, Cologne (2025)
50,00 €
ISBN-13: 978-3836594448 (English)

beyond our vision

August 28, 2025 // Thorsten Naeser

And last but not least, a visual treat for anyone interested in phenomena from the world of high speed. Photographer Anand Varma has perfectly captured the flight behavior of a hummingbird. The animal was squeezing through a narrow oval hole when Varma pressed the shutter release. During the exposure, he triggered three flash pulses in quick succession.

Hummingbirds flap their wings up to 100 times per second. Our eyesight is clearly overwhelmed by such high-speed actions. Anand Varma used a sophisticated flash technique to capture a single wingbeat of a hummingbird during its complicated route through the obstacle. The photographer thus provides ornithology with exciting insights into the flight behavior of these colorful birds. The photo reportage on these lightning-fast aerial acrobats appeared in National Geographic magazine. Now the pictures can also be admired in the book 'Verborgene Welten.'

In it, Varma and other photographers present us with perspectives and phenomena that would remain hidden to the naked eye. The entangled shape of an embryonic stem cell. The dynamics on the surface of the sun, the dazzling glow of a supernova. Never seen before? Then this book offers you the opportunity! 300 fascinating photographs reveal the intricate details of the human body, nature, technology, and space.

varmaphoto.com/hummingbirds

Bildband Fotografie – Verborgene Welten
Anand Varma & Susen Truffel-Reiff
National Geographic Deutschland (2023)
49,99 €
ISBN-13: 978-3987010415 (German)

pulse – the magazine of attoworld *(volume 6, 2025)*

publisher: **Prof. Ferenc Krausz**
editorial staff: **Thorsten Naeser,**
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design: **Dennis J.K.H.Luck**

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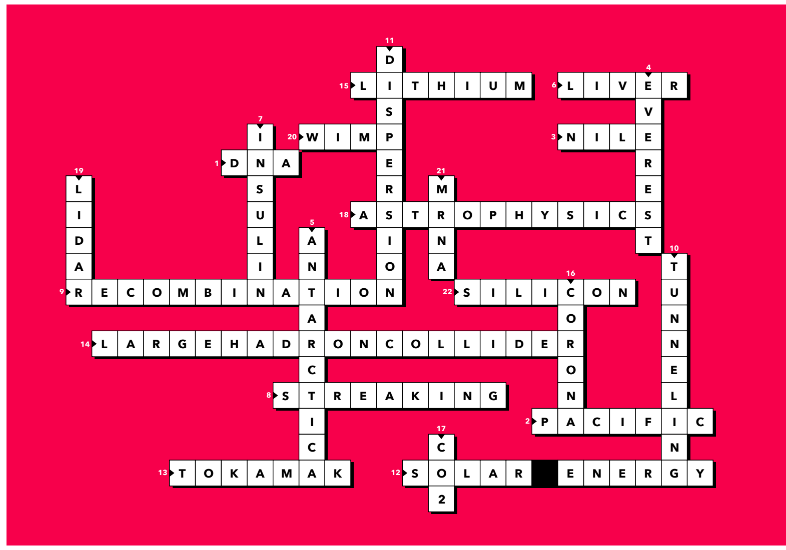
cover image:
Thorsten Naeser (Photo) & Dennis J.K.H.Luck (Artwork)
A.O. with A.I. 'DALL·E' (drop of blood)
Many thanks to Briana Cigan, who volunteered as a model for the cover shoot!



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), which push the frontiers of science in long-standing strategic collaboration with the Center for Molecular Fingerprinting (CMF) in Hungary and the Chair of Laser Physics at the University of Hong Kong, and in partnership with clinics and research institutions across these countries and beyond.

We pursue – supported by startups such as UltraFast Innovations GmbH (UFI) and PULSED GmbH – the transfer our technological developments to research institutions and enterprises all over the 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.

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.

“Science is the torch which illuminates the world!”

[Louis Pasteur]

Knowledge creates the future. Curiosity and education are the cornerstones of our prosperity, and it is important to promote them from an early age. However, in times of war, children and young people suffer from a lack of educational opportunities. This robs them of their childhood and the chance for a self-determined future, even though it is this very generation that must later rebuild society with knowledge and expertise.

The **Science4People** e.V. association supports children and young people whose educational opportunities are limited by armed conflicts. The organization was founded by Prof. Ferenc Krausz, Nobel Prize laureate in Physics in 2023.

Our aim is to improve educational opportunities and access to knowledge for children from war-torn regions. The focus lies on donation-funded support programs that provide young people in Ukraine with educational opportunities and prospects for personal development.

You too can help make the invaluable assets of education and knowledge accessible to disadvantaged students. **With your donation, you help us help others.** Who knows? Perhaps the next Nobel Prize winners will be found in today’s war zones.

WWW.SCIENCE4PEOPLE.ORG

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