the newsletter of attoworld

volume 3 (2022)

pulse

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see page 43

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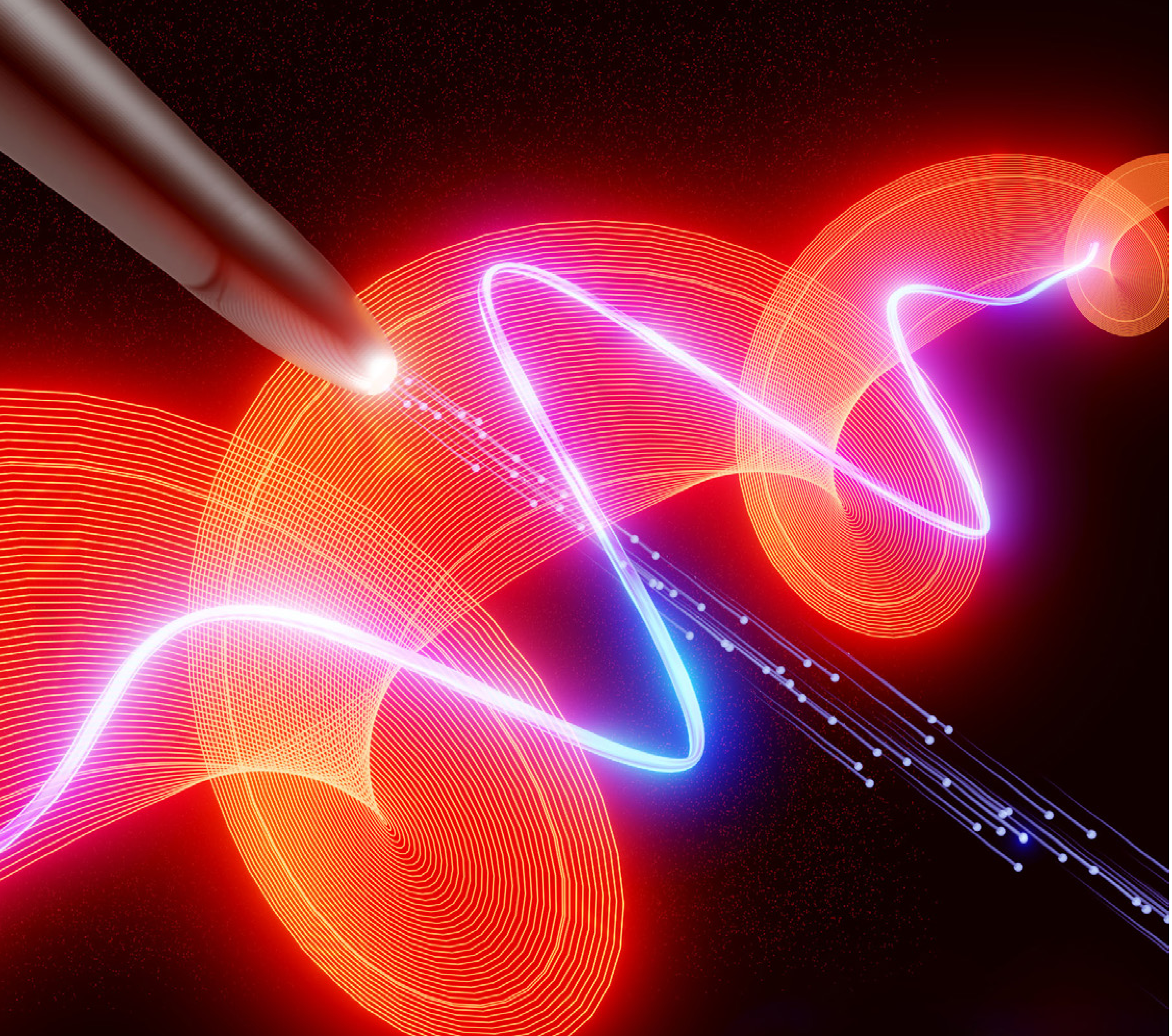
LMU



A nanometric needle tip interacting with a few-cycle femtosecond laser pulse and a near-petahertz vortex field. The femtosecond pulse induces an ultrashort current of electrons that escape from the tip. The vortex field is probed by measuring the change in the electron current it induces. The localized field enhancement at the tip of the needle facilitates the spatial resolution of the helicoid wave front of the vortex field within the laser focus. Illustration: RMT.Bergues

dear reader!

Welcome to the latest issue of "pulse", the magazine of the ATTOWORLD team. As you browse through this issue, one thing will be sure to strike you: The range of topics covered in the articles has reached an enormous breadth.

We have attracted a wide variety of authors to contribute to this publication. Starting with our core business, attosecond physics, through medical issues, to artificial intelligence. But art and culture in connection with the natural sciences are also a topic, as is the communication of science by our school laboratory PhotonLab, which now inspires even school beginners for physics with a specially designed audio play. Likewise, we naturally want to keep them up to date on our aid activities in Ukraine, as the article on the "Science4People" initiative founded by Ferenc Krausz and his team shows. All of this adds up to a broad spectrum that our authors deal with. And they are all part of the ATTOWORLD team.

This shows us once again that a colorful mix is the quintessence. Ultrafast laser science combines the most diverse disciplines in our group. Here, laser physicists work together with biologists, chemists, and IT professionals. They are supported by a great administrative team, by an extremely skilled technical team, as well as by PR- and knowledge transfer experts.

[Thorsten Naeser]
Head of Public Relations

dear attoworldians and friends of attoworld!

Advancing science and technology is not an end in itself. Beyond satisfying our natural thirst for deeper insight into how the cosmos works, it is to improve our living conditions and, on the long run, ensure our survival[1].

At ATTOWORLD, we are privileged to be allowed to contribute to several of these grand goals.

Advancing our Just Cause[2] requires insight into the microcosmos of biological molecules and their interaction with light. It is this interaction which we harness for observing miniscule changes in the composition of human blood plasma and possibly other biofluids. Moreover, relating these changes to those in human physiology. For the purpose of probing and monitoring human health. Towards the end of detecting wellness-disease transitions early enough to allow medical interventions or other measures to prevent evolutions towards severe conditions. Health conditions that may impair the quality of – or even threaten – life.

To be successful, we shall also have to advance the generation and measurement of light waveforms with utmost precision and sensitivity. To this end, we will need to look very deeply into the interaction of these light waves with solid matter, serving both for the generation and for the detection of these waves. Gaining ever deeper insight into the interaction of light with organic and inorganic matter and ever better control over these interactions will be instrumental in allowing physics to shape the future of healthcare.

For continuing journeys that can only be started but by no means finished by our generation, support of the next generation must be among our utmost priorities. Of the generation that is currently being deprived of their homes, schools and play-grounds in warn-torn Ukraine. Recognizing that they depend on our support and help, we have established the non-profit association Science4People (S4P)[3]. We thank all those who allowed us to undertake efforts to alleviate the need of children in Ukraine with their donations. Facing a winter without continuous supply of electricity, they need our help and your continuing support more than ever before. Every small donation that you continue to make for Science4People will soothe their suffering and help maintain their trust in a better future.

I thank all ATTOWORLDIANS and our scientific as well as humanitarian partners for all the wonderful interactions that helped us advance science and turn fear into faith.

I wish you Merry Christmas and a Peaceful, Healthy and Prosperous New Year!

[Prof. Ferenc Krausz]
Director CMF & MPQ
Chair of Experimental Physics LMU
Chair of Science4People

[1] https://yurimilnermanifesto.org
[2] www.attoworld.de/our-vision
[3] www.science4people.org

Photo: Zydbanka

“Our actions may seem like drops in the ocean. But those drops improve children’s lives and development. They leave positive traces in the adults of the next generation. Traces that might make the sound of air raid sirens, the cold of bunkers and basements, the sound of bombs hitting, the memory of fleeing for days, fainter. Turn fear into faith, terror into trust, and loss into courage. We help them paint on canvas, forget with play, sing out all their pain, anger and fear. We give them the certainty that someone is always there for them and they can count on help at any time.”

[Adrienn Dávid]
Chairwoman of the Ukraine-based NGO
Tabula Rasa – *for the next generation* and
Vice Chair of Science4People

your donation makes a difference

science4people.org

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every donation makes a difference

"It began like an ordinary Thursday morning. I kissed my children goodbye for school. Minutes later they were back and standing in the door. I will never forget the look of terror and incomprehension on their faces. Since that Thursday morning, the war has been raging without any prospect of an end. Marked by innumerable victims, unimaginable destruction, fear and suffering".

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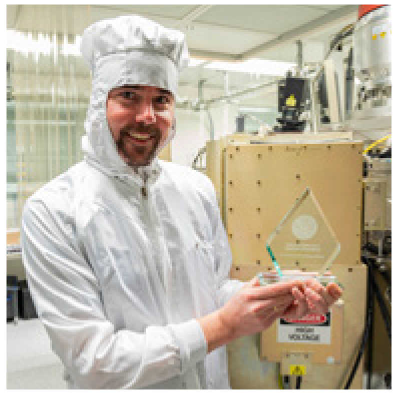
The function of cells in our bodies project into the molecular makeup of biomolecules in the cell-free liquid phase of our blood.



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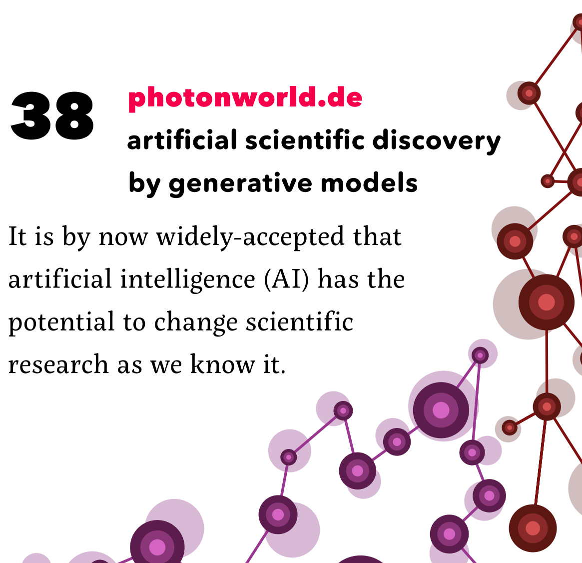


attosecond spectroscopy 2.0

*november 25, 2022 // Dr. Nicholas Karpowicz &
apl. Prof. Dr. Vladislav Yakovlev*

In September 2001, shorter-than-femtosecond bursts of extreme-ultraviolet light were seen in a lab for the very first time. This event immediately captured the interest of scientists around the world. How short were these pulses? How to measure them? Is it possible to generate isolated attosecond pulses? What are they good for? How to make them yet shorter? Attosecond science was born, attracting brilliant experimentalists and occupying brilliant minds. The dreams were big: to detect and control electron dynamics that used to be way too fast for direct time-resolved measurements. With the excitement of a child who gets a new toy, scientists began pushing the boundaries of what was possible. The experimental and theoretical toolset had to be developed, new techniques for generating and measuring attosecond pulses had to be invented, attosecond spectroscopies had to be established.

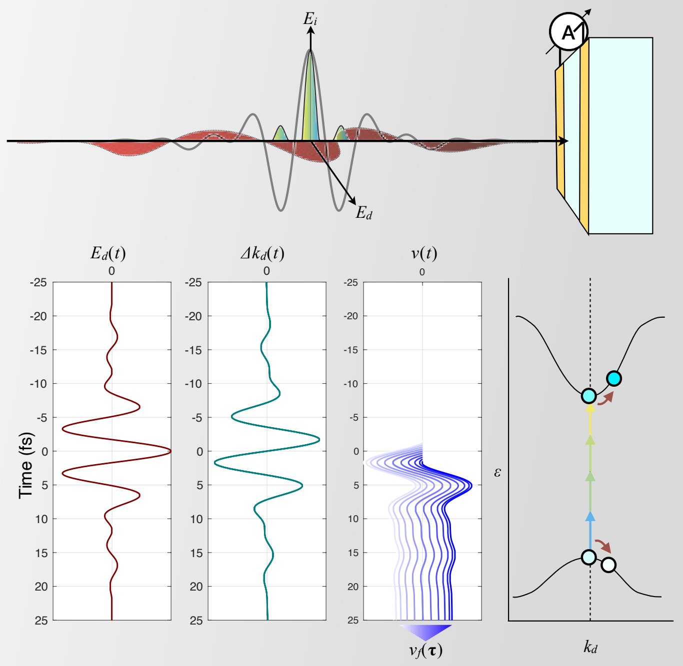
In the future, we envision that AS 2.0 should produce a long list of experiments where the direct measurement of broadband light waves provides a key to unlock the information about the internal dynamics in atoms, molecules, or solids. Photo: Thorsten Naeser

Looking back, attosecond science may not have met all the expectations in producing unexpected scientific discoveries, but it made tremendous progress at many frontiers. As its tool matured, the research focus shifted toward applying these tools. Ingenious experiments taught us many previously unknown aspects of ionization, high-harmonic generation, molecular dissociation, electron motion in solids and other processes where attosecond-scale dynamics are either inherent to a quantum system or emerge as a result of the interaction between a strong optical wave and electrons.

This basic research has been fascinating, but even the richest research field sooner or later enters a mature state, where the low-hanging fruits have been harvested, and that metaphorical child who was so excited about that new toy has grown up. While the stream of new ideas is still flowing, one observes a growing demand to transform the outcomes of curiosity-driven basic research into useful applications. At the same time, even a very mature research field has a chance to renew itself: to redefine its major goals and take advantage of some exciting new opportunities. This is why a big part of the ATTOWORLD team has devoted their efforts to what we call "Attosecond Spectroscopy 2.0" (AS 2.0).

The first generation of attosecond spectroscopy (AS 1.0) relied on attosecond extreme-ultraviolet (XUV) pulses produced via high-harmonic generation driven by a few-cycle laser pulse. AS 1.0 requires multi-meter-scale complex vacuum beamlines for generating and using attosecond XUV pulses, which has hampered the proliferation of this powerful metrology. The second-generation attosecond spectroscopy, AS 2.0, also relies on a highly nonlinear process to create an attosecond temporal gate. Unlike in AS 1.0, a high nonlinearity is utilized without generating an attosecond pulse of light. Instead, multi-photon absorption injects charge carriers on a sub-cycle time scale.

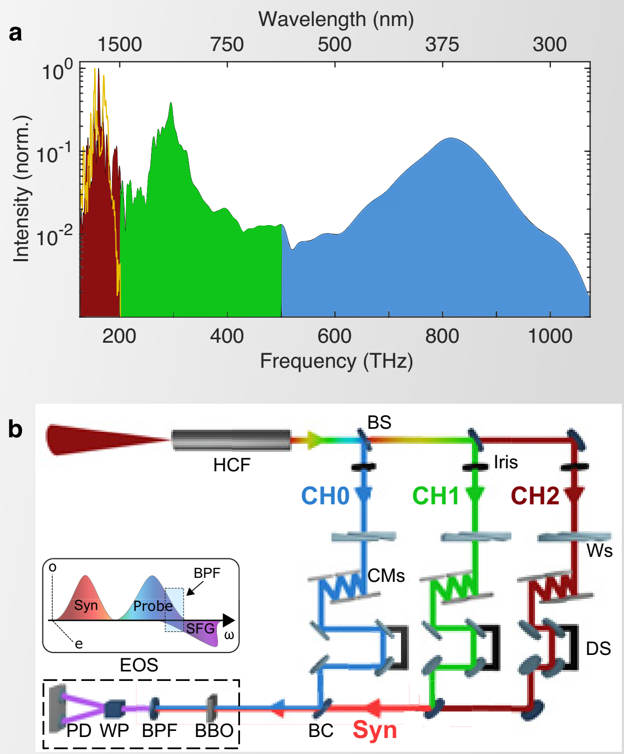
Let's put these developments in the context of how attosecond science in our group has progressed. One landmark publication, "Delay in Photoemission" by M. Schulze et al. [***Science* 328,** 1658 (2010)], from more than a decade ago, showed some of the power of attosecond pulses to pick out small timing details of physical events. This was due to how attosecond streaking measurements returned a waveform of light, phase information included. Phase shifts amounting to a few milliradians could be resolved by comparing the waveforms measured by electrons emerging from different photoemission processes. This led to the natural question – what other effects could cause a similar shift in a waveform? An important realization was that it didn't have to come from anything involving an attosecond pulse at all – we could equally well look at the laser field being modified solely through its interaction with matter.



A sketch of Nonlinear Photoconductive Sampling, which uses carrier injection caused by an intense injection field (E_i) to gate a weak driving field (E_d).
Adapted from Sederberg et al., *Nature Communications* 11, 430 (2020)

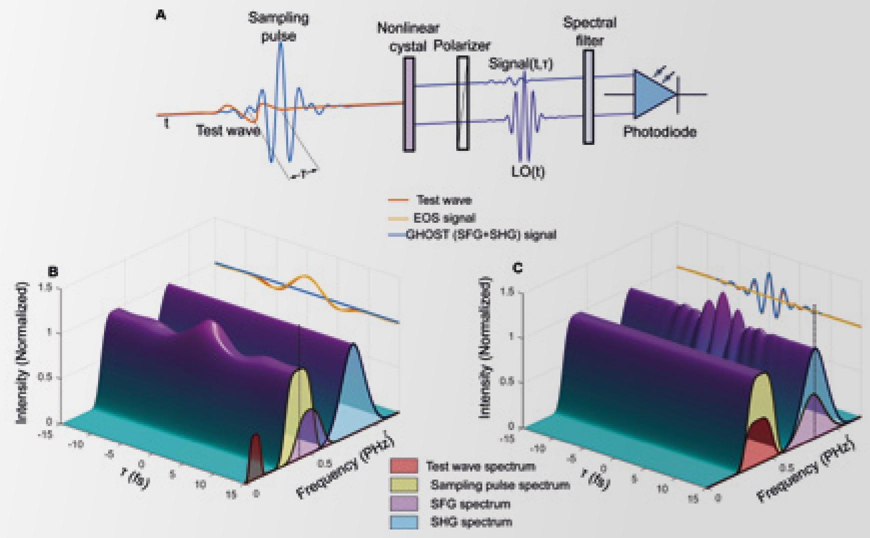
This was exactly the case in “Attosecond nonlinear polarization and light-matter energy transfer in solids” by A. Sommer, et al. [***Nature* 534**, 86 (2016)]. In this case, small modifications of the waveform of a visible-light pulse carried cycle-by-cycle detail about the transfer of energy between an intense light wave and a solid. In this case, the attosecond pulse’s job was only to read out the electric field after all of this happened, like an oscilloscope providing the time dependent field. In fact, we realized that, by utilizing the same ultrafast energy transfer (stored in the form of free carriers in the solid if energy was left behind), we could replace the attosecond pulse all together, using nonlinear optics and optoelectronics to work as our high-speed oscilloscope.

This idea has proved to be fruitful, and multiple approaches were developed for measurements of broadband electric fields oscillating at optical frequencies. One of them is nonlinear photoconductive sampling, which utilizes the fact that multiphoton injection of charge carriers is efficient only within a fraction of an intense laser pulse, where its electric field is strongest. This abrupt change in a medium’s conductivity allows one to measure the electric field of a test pulse that is co-applied to the material. We first demonstrated NPS in solids [Sederberg et al., ***Nature Communications* 11**, 430 (2020)], where field sampling could be achieved with over a bandwidth approaching 1 PHz. To avoid irreversible degradation of the medium, the dynamic range of the field strength measurement barely exceeded a factor of 10. Extending the concept to ambient air as the nonlinear medium increased the dynamic range whilst still allowing a bandwidth of 0.7 PHz [Zimin et al., ***Optica* 8**, 586 (2021)]. In order to further improve the signal-to-noise ratio and the dynamic range of detectable field strengths, we investigated all-optical schemes for measuring optical waveforms [Ridente et al., ***Nature Communications* 13**, 1111 (2022); Zimin et al., in press], where a fast gate is formed by nonlinear wave mixing.



An ultrashort 2-micron laser pulse produces a continuum broad enough to both synthesize a single-cycle IR-visible light field, but also directly measure its waveform via electro-optic sampling.
Adapted from Ridente et al. *Nature Communications* 13, 1111 (2022)

In the future, we envision that AS 2.0 should produce a long list of experiments where the direct measurement of broadband light waves provides a key to unlock the information about the internal dynamics in atoms, molecules, or solids – the information that is carried by a light wave after interaction with matter. The progress along this path will largely depend on how our tools for optical field detection develop. In particular, improving the stability of light sources would greatly increase the power of AS 2.0.



A new approach to obtain the electric field through all-optical means, to be revealed in an upcoming publication.
Adapted from Zimin et al., *Science Advances*, in press

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attoworld.de/atto-20

every donation makes a difference!

november 25, 2022 // Dr. Veit Ziegelmaier

"It began like an ordinary Thursday morning. I kissed my children goodbye for school. Minutes later they were back and standing in the door. I will never forget the look of terror and incomprehension on their faces. Since that Thursday morning, the war has been raging without any prospect of an end. Marked by innumerable victims, unimaginable destruction, fear and suffering."

Much of what we take for granted is currently not the case in war torn Ukraine. In many places, the power supply has collapsed and people are struggling with the difficulties of blackouts lasting for days. At present, power generators are urgently needed.
Photos: Zydbanka / Tabula Rasa / Science4People / Győző Karácsony

With these very personal words Adrienn Dávid, from Transcarpathia in Western Ukraine, describes her impressions of February 24, 2022, the day when the Russian invasion of Ukraine began. Dávid is the director of a local youth center. Together with the Ukrainian youth organization STAN, she has been vividly engaged in advocating peace, integration and international understanding with the young people entrusted to her for years. Looking back, she recounts:

"We couldn't foresee, how pressing these concerns are about to become. Overnight, our team transformed into a humanitarian aid organization. Thanks to immediate support from Europe, we were able to provide shelter for the first wave of evacuees from Kharkiv, distribute food and basic items for survival to people living in combat areas. From the first day on, children and adolescents have undertaken everything within their powers to integrate their fellows from Eastern Ukraine into the local community."

Their exemplary behaviour inspired Dávid to establish a new NGO, TABULA RASA, specifically devoted to the needs of the next generation. Of the generation which is supposed to rebuild our country one day.

Ferenc Krausz, head of ATTOWORLD's research groups, was also deeply moved by the events at the end of February, which led to the outbreak of war. These brought suffering, hardship and terror to the Ukrainian population as well as upset the political world order. He wanted to help and, as a native Hungarian, inform himself about the current situation in the neighboring country of his homeland. Together with staff at his chair in Munich and at the Max Planck Institute of Quantum Optics, he founded the Science4People initiative to launch an appeal for donations within the globally networked scientific community and to recruit high-ranking supporters from the scientific world. Science4People's main focus is on supporting children and young people in order to ensure that they continue to receive a school education even under the terrible conditions of war. Hence, to provide them with a perspective for their and the country's future. Together with the Hungarian Aid Association (HIA), Krausz arrived in the small western town of Bakosh in March 2022.

Here on site, he met the dedicated Adrienn Dávid and her team, and immediately offered support by his recently launched Science4People initiative. For even though the western part of the country, bordering Hungary, was largely spared the fighting in the east, the region is a catch basin for refugees from the combat zones. As a result, the local elementary school was immediately converted into a refugee shelter, which in turn meant that school classes could no longer be held as usual. Krausz and his team, in close cooperation with the local youth organization STAN and TABULA RASA of Adrienn Dávid, subsequently organized and supported several aid deliveries to make the improvised living conditions on site a little more comfortable. In addition to necessities such as clothing and other supplies, Science4People (S4P) also delivered toys for the

Toys for small joys. S4P's first aid delivery brought toys and teaching materials such as tablets to an elementary school in Western Ukraine that had been converted into a refugee shelter. The latter were used to continue schooling in the region via distance learning.

very young as well as educational materials and tablets. The latter were used to set up on-site distance learning from home for students in the region, whose schools are currently accommodating shelter seekers. Repairs and renovations within the school premises and another building intended for use were also envisaged. In addition, S4P and its local partners support educational initiatives and events of local youth, such as an auction of pictures painted by refugee children under the impact of war. The proceeds of the auction will be used for other smaller support measures.

With the aid of our supporters we were able to help little Mira, who suffers from food intolerances and needs special diet. Sometimes it's the little things that make a big difference.

But also very concrete and individual help in the supposedly small is needed as the example of little Mira shows. Three-year-old Mira fled with her mother from the city of Nikopol in southeastern Ukraine to Transcarpathia because of the constant bombing. She suffers from the metabolic disorder phenylketonuria, which is why she has to follow a strict diet. After local volunteers ran out of appropriate supplies, they asked S4P for help through our Transcarpathian partner organization TABULA RASA.

In addition, direct relief efforts are being organized collectively for those still persevering in the contested areas. All these supplies are only ever possible together. This includes committed local partners like the team around Adrienn Dávid. They know about the needs of the people living there and take care of the distribution of the relief supplies on site. Even the smallest donation makes a difference collectively. Ferenc Krausz continuously promotes this in the scientific community and at his public lectures. Be it in Jerusalem at this year's award ceremony of the prestigious Wolf Prize for Physics, which he was awarded and whose prize money he donated to Science4People's initiatives, or most recently at the Einstein Lectures of the Freie Universität Berlin, which invited Krausz as this year's speaker. Meanwhile Krausz has also brought Adrienn Dávid on board as co-chair of the initiative, which is constituted as a registered association, in order to strengthen the cooperation between S4P and its partners in Ukraine, who ensure that the aid also arrives and is used in a targeted manner. She descri-

Life in Ukraine: The civilian population finds temporary protection from attacks in bunkers and cellars. But it is the children who suffer the most and whose future is at stake.

bes the cooperation as follows: "Thanks to a strong partnership with the world-wide initiative of Prof. Krausz, Science4People, we have already been able to tackle first projects. We could improve education, personal development and living conditions of children and adolescents. By connecting hundreds of pupils from several villages, whose classrooms were turned in to shelter for refugees, to efficient distance learning. By equipping a regional Children's Shelter with toys and clothing for their occupants, to mention only first steps."

It is also important to her to make clear the value of every single donation, no matter how small, in view of the devastating circumstances currently prevailing in large parts of the country.

Life must go on and you can help to give children and young people at least some perspective for their still uncertain future.

"Our actions – enabled by your support – may seem like a drop in the ocean. They are not, no! They improve children's lives and development. They leave positive traces in the adults of the next generation. Traces that might make the sound of air raid sirens, the cold of bunkers and basements, the sound of bombs hitting, the memory of fleeing for days, fainter. Turn fear into faith, terror into trust, and loss into courage. Every child's life is a priceless miracle."

Every small donation that you make for Science4People will make a contribution to preserving those miracles. And give them trust in a better future.

For more information and to find out how you can make your own individual contribution, please visit:

science4people.org

“We are aspiring to contribute to solutions to important questions and problems facing humanity”
[Prof. Matthias Kling]

november 28, 2022 // Thorsten Naeser

A year ago, Matthias Kling emigrated to the USA with his family. In addition to his research group, which he continues to supervise as a Max Planck Fellow at the Max Planck Institute of Quantum Optics, he has now established the research group “Ultrafast Electronics and Nanophotonics” at Stanford University. Here, in an interview with Thorsten Naeser, he talks about his new life and what is currently keeping him busy in research.

You’ve been in the USA with your family for a year now. How did the move work out?

It was a very drastic experience, especially because we moved as a family of four with all our household goods, in the middle of a global pandemic. With our small children, eight suitcases, two child car seats, prams, a lot of hand luggage, and a cat, we set off on our journey just before Halloween. The rest of our household goods were shipped by container. The day of the move felt like the longest day of our lives. But everything went well. We had friends by our side on both the German and American sides who helped us cope with the departure and arrival. We had to wait six months for our container from Germany because of the pandemic, which felt very long. It creates a kind of homesickness, not for home, but for the ’life’ that comes with all the personal things. It felt like Christmas when the container finally arrived.

How was the adjustment to American conditions?

The first three months felt more like a holiday. But after that, reality set in and it took a long time to establish a new normality. In principle, everything is different. This includes many otherwise simple things in life, such as a bank account, driving licence, insurance, or even suitable doctors. The health system is completely different. It took along time to understand which doctors were in-network or out-of-network, and what insurance really covered. Our children are our priority. They were placed in a very good English-speaking kindergarten from the beginning. In the meantime, English has become their second mother tongue.

What is the biggest difference between life in Germany and in the US?

That depends a lot on where you live in Germany and even more on where you live in the US. I can only directly compare life in Bavaria and California. In principle, the standard of living and also the recreational value are very high. In the USA, there is a basic friendliness in dealing with each other that we like very much. On the other hand, the social and health care systems in Germany are on a level that you can only wish for in the US. In Silicon Valley, where we now live, science and creativity are very much appreciated and promoted. Here, the great challenges of humanity, such as climate change or the next technology revolutions, are topics that people deal with every day. That is very inspiring.

You have established a second research group at Stanford University? What topics do you deal with there?

In my group we deal with photonics on extreme length and time scales. Applications include research into new materials for quantum technologies, ultrafast nanoelectronics, and renewable energy generation (uen.stanford.edu). Together with colleagues from Stanford University, we are also looking at applications of photonics in sustainability. One example is a project on the emission and dispersion of pollutants from forest fires and their impact on our health. Forest fires are a very topical issue that we need to address globally.

At SLAC, we use the Linac Coherent Light Source (LCLS) free-electron laser (FEL) for this research, in addition to ultrashort laser technologies. At the LCLS, where I am Head of Science, Research and Development (lcls.slac.stanford.edu/depts), we can generate very high-energy X-ray flashes with pulse durations in the attosecond range. We are currently commissioning the new generation LCLS-II. LCLS-II is based on a superconducting linear accelerator, can generate pulses with repetition rates up to 1 MHz, and thus has about 10,000 times more power than LCLS. A good report on LCLS-II can be found here: www.youtube.com/watch?v=6XTII6qaAxc.

What is it like to lead two research groups at different times?

It is certainly not easy and requires very high prioritization to do it successfully. A key factor is that there are experienced scientists on both sides who support the supervision of postdocs and PhD students. In Germany, we are part of the ATTOWORLD team. This affiliation provides a stable framework, the infrastructure, and the necessary team spirit. In the USA, we can use the new beginning to set accents with regard to new research goals. These include research with FELs and applications of photonics in sustainability. Our horizons have expanded greatly at SLAC and Stanford University. We are looking at approaches for solutions to important questions and problems facing humanity.

Do you have one or two tips for students or doctoral candidates if they want to work in the USA?

My tip would be to make contacts early on. The barriers become much smaller if there has already been a conversation at a conference or following a lecture at your home institute. Take every good opportunity to present your research and yourself. There are many exciting opportunities to work in research and development in the US. The experience of having lived and worked in the US is very enriching. Another tip is not to give up so easily. As long as you keep the goal in mind, it can be realised, even if often not via the path you first imagined.

Are there career opportunities in your research group for our attoworld members?

Absolutely! They are either directly in my group or at SLAC. Besides the possibility to join us as a PhD student or postdoc, there is also a tenure-track career at SLAC. I am happy to support your application for funding from e.g. the DFG, Alexander von Humboldt Foundation, or EU. These grants come with many benefits, such as a lifelong network, a stronger CV, and often family allowances. My door is always open – so get in touch!

More information about Matthias Kling:
uen.stanford.edu

“Science with virtual coffee”

[Dr. Oliver Völkel]

august 22, 2022 // Thorsten Naeser

The last two years have brought scientific exchange into a new era. Virtual communication between researchers around the globe has been refined and taken to a new level. Young researchers at the Max Planck Institute in Heidelberg have also been thinking about how the positive aspects of global scientific exchange can be further perfected. To this end, they have launched the platform sci-an. Their co-founder Oliver Völkel explains how it works and what is planned.

You launched sci-an during the Corona pandemic. Can you briefly explain what the project is about?

sci-an is a virtual event platform for scientific networking and discussion. Our goal is to make the scientific process more efficient, sustainable and inclusive. Since the number of new talents in science increases rapidly every year worldwide, we need new ways to enable young scientists in particular to start an international career.

life within attoworld

The sci-an team. Photos: The sci-an team / Kimberly Kober

How does such an entry take place?

This entry usually happens through networking at scientific conferences. Unfortunately, these international conferences are often associated with numerous ecological burdens and economic obstacles. As a result, many young talents are not recognised, which is enormously damaging to their careers and to science as a whole.

What are you doing about it?

By combining virtual events with targeted networking tools, sci-an offers an easy-to-use alternative worldwide.

How is sci-an structured?

sci-an consists of a combination of an event management tool, a virtual 3D conference hall and personal profiles for scientific content and discussions. The core of our platform is the specially developed 3D conference hall for coffee breaks, poster sessions and general networking events. All participants are represented by avatars linked to their scientific profile and content. Conversations are automatically established through spatial proximity to others, resulting in a lively conversation landscape among each other. Through the informal setting alongside the professional presentation of the scientists, we enable a new form of virtual networking.

What does participation cost?

Currently, our project is funded by an EXIST start-up grant from the Ministry of Economics and Climate Protection, as well as by the Startup Incubator Programme of the Max Planck Society (MAX!mize). This funding currently allows us to offer sci-an free of charge to all interested parties worldwide. I would therefore like to invite all scientists to use sci-an for themselves and their next events to experience the benefits of virtual networking in science for themselves.

More information about the platform:
sci-an.com

“we are looking forward to our vision of a new type of healthcare”

[Dr. Alexander Weigel]

november 08, 2022 // Dr. Veit Ziegelmaier

The laser science group of the Center for Molecular Fingerprinting (CMF) around Dr. Alexander Weigel in the ATTOWORLD team combines laser research with engineering approaches to develop new technology for health monitoring, using a novel technique called infrared molecular fingerprinting. For this, the team uses ultrashort infrared pulses to excite the molecules in a human blood sample, and then to record with a very sensitive detection technique the molecular response. In this interview Alexander Weigel gives an overview over the research activities.

What exactly is your research about?

In the CMF laser science team, we combine laser research with engineering approaches to develop new instruments for health monitoring, using a novel technique called infrared molecular fingerprinting. The concept behind it is the following: we use an ultrashort infrared pulse to excite the molecules in a sample and then record with a very sensitive detection technique the molecular response. In this endeavor, we are closely working together at ATTOWORLD with the teams of Ioachim Pupeza, Nicholas Karpowicz and Vladimir Pervak to develop our technology towards ever higher sensitivity and reproducibility. Together with the team of Mihaela Žigman, we use then our instruments in large-scale human blood-sample studies to identify infrared fingerprint signatures that indicate the development of possible diseases.

Could you explain in more detail, what happens during a measurement?

You can imagine that in a similar way as hitting a gong with a mallet and then listening to the decaying vibrations of the gong. In our case, we use our ultra-short infrared pulses as the – “mallet” and strike not a gong, but molecules in a sample. We then “listen” to the electric field emitted by the vibrating molecules as a response to the excitation. While the acoustic vibrations from a gong can be readily recorded with technical means, for example a microphone, the electric-field oscillations of light are much faster, so that they cannot be directly measured with any available electronics. In order to measure them, we need to be faster – and the fastest that is available in nature is light itself. In reality, we use other, ultra-short pulses with only a few femtoseconds duration to scan over the emitted infrared response. Just to give you a scale: A femtosecond is only a millionth of a billionth of a second. Coming back to the picture of a gong being hit: You can imagine that the vibrating response depends on the size, shape and material of the gong. In the same way, the response of a molecule, after being excited by an ultrashort infrared pulse, depends strongly on the size, shape and the chemical bonds of the molecule. Therefore, we can use the infrared response to distinguish between different molecules. For health monitoring we are interested in analyzing samples of human blood.

Why is blood such an interesting liquid?

Blood is a complex liquid and contains a huge variety of different molecules. Biologically relevant are, for example, proteins, carbohydrates, lipids or nucleic acids. With our technique we measure the complex vibrational response signal of the blood sample that we call its molecular fingerprint. It contains response contributions of all molecules in the sample. While we may not be able to distinguish each individual molecule, the fingerprint signal still represents the complex composition of the blood sample, and is very sensitive to changes in molecular composition.

What is the vision behind it?

Our vision is to identify characteristic signatures in the fingerprints of blood samples that are specific to human health. Human blood is the fluid interconnecting all parts in the human body. Therefore, when a disease evolves, we expect small changes to appear in the molecular composition of the blood sample. The idea is that if we are sensitive enough to detect these changes in the molecular fingerprint signal, we can possibly diagnose any medically-relevant deviations from a healthy state by a simple blood-based measurement. The Center of Molecular Fingerprinting has already started a large clinical study involving thousands of individuals to be followed over years to be investigated with our newly developing technique.

What are you working on in particular?

The task of my team is to provide the technology and develop the instruments to make this vision reality – to one day have an in-vitro diagnostic test that can, based on a drop of blood, be used to probe human health. First of all, we need powerful and extremely short infrared lasers. Part of my team is constantly pushing the limits of what is possible with today’s laser technology, and is developing new powerful femtosecond infrared sources. On the other side we are also working on the research and development of new detection solutions, not only on the optical and electronics side, but also on the data processing side to reach ever higher levels of detection sensitivity. Our

Inspecting the first prototype of the next-generation Cr:ZnS laser in the laboratory.
Photos: Thorsten Naeser

life within attoworld

engineers combine then our research results into ultra-stable and user-friendly instruments to measure and compare human-blood samples from large-scale campaigns over many years.

You are leading an international team. How many team members work in the group and from which nations do they come?

The CMF laser research team has been rapidly evolving over the past slightly more than two years. Meanwhile, we are 15 team members, including myself. The multi-nationality of the team really amazes me every day: For the 15 members, I count 10 different nationalities, ranging from Germany over Greece and Switzerland to Nepal, India, Iran and others. The multi-national spirit is one of the big advantages of an academic environment. I really enjoy the diversity in the team. It is fascinating to constantly learn more about the different cultural backgrounds. At the same time, everyone is working together as one team with great mutual respect and without preconceptions.

What are your next research goals?

On the one hand, we are constantly striving to improve our laser technology that is the base for the blood-based assay development. Our next-generation instrument will be based on Cr:ZnS laser technology. This new type of ultrafast lasers is particularly suitable for generating infrared pulses. The exact shape of the infrared pulses that excite the sample also influence the molecular response signal we measure. It is therefore extremely important to create reproducible infrared pulses from the laser. We therefore actively stabilize our laser systems to exactly maintain the full waveform of the pulses over and over again.

Naturally, our detection needs to keep pace with the laser development: We need to find ways to measure with the same spectral bandwidth that our laser pulses provide. Not only that: We want to record in a single measurement the strong infrared excitation pulse simultaneously with ever weaker response signals. The property of largest measurable signal versus smallest detectable signal is called "dynamic range". Achieving an extremely high dynamic range requires both: research and development on the optical side of the detection, as well as the development of new electronic detector solutions. The ultra-low-noise performance of our lasers is another crucial parameter to reach highest sensitivity in our measurements. Any noise in our laser output directly translates into measurement noise, which can hinder us from seeing small changes in the molecular fingerprint response. In our latest-generation lasers we use pumping with telecommunication-grade semiconductor laser diodes as one of the key technologies to achieve extremely low fluctuations of the laser. In our instruments we are synchronizing two lasers to perform extremely fast measurements – so fast that during a single scan many of the residual noise contributions are frozen in time.

We are just completing a big experiment campaign, in which we are measuring more than 5000 human blood samples from the clinical studies that the BIRD team has been running with the LMU clinics in Munich. Here, the focus is very different – we are looking at whether severe diseases like commonly occurring cancers, are detectable with infrared molecular spectroscopy. The team around Mihaela Žigman is evaluating whether blood-based infrared fingerprints of either lung, breast, prostate or bladder cancer carry fingerprint signatures that are specific to these kinds of cancers. If so, that would be a game changer in the field of in vitro diagnostics: Being able to spot cancer in a non-invasive fashion.

You published an important paper in Nature Photonics in May 2022. It's about making a push in the mid-infrared region. Can you briefly outline your research results and possible applications?

In this publication we showed, that we can compress the output of our Cr:ZnS lasers to only around 7 fs pulse duration. If you think about the oscillating electric field of light, the pulses are so short that they contain only a single cycle of the electric field. We then converted these exceptional pulses very efficiently into single- or even sub-cycle mid-infrared pulses that can be used in future to excite our blood samples. Compared to our previous technology, these pulses have about four times larger spectral coverage,

Alexander Weigel (left) and Maciej Kowalczyk (right) observing the active stabilization performance of the new lasers.

allowing us to access much more information about the molecules in a sample. We can also actively control the waveform of these pulses with extremely high reproducibility, opening up completely new applications in several other fundamental research fields.

When do you think your method will one day find its way into medical practice?

As I said above, we are already taking blood-sample measurements with fingerprinting technology, today. Concerning the next-generation Cr:ZnS technology, we are working hard to develop and demonstrate the main working principle of the new instrument in the upcoming months, and we expect first measurements on actual blood samples with the new instrument next year. Still, it is a long way from taking first measurements to having instruments being used for regular medical diagnosis. We are talking here about years of hard work ahead of us, plus clinical trials etc. On the measurement side, we need to evaluate first our technique on many blood samples, and learn how to take into account, for example, the diversity of the human population and individual lifestyles, and their influence on our measurements. Over the next years the Center for Molecular Fingerprinting will establish a new large institutional building in Budapest, with the capacity to store and measure a large number of human blood samples. There is a lot of research ahead of us in the upcoming years, before we can establish our technique as a regular diagnosis tool, and me and my team, and all collaborators are working together towards making our vision reality.

More information about Alexander Weigel:
www.attoworld.de/cmf-laser-science

team news

ALBATROSS

Pulsed: a new spin-off

december 5, 2022 // Dr. Nils Haag & Dr. Nathalie Nagl

This year was a very special one for us! In summer, Ferenc initiated Pulsed, a new spin-off from LMU and MPQ, and we eagerly joined this adventure.

Over the past decades, the ATTOWORLD team has demonstrated novel ultrashort-pulse laser systems and laser-based detection methods, opening up completely new fields of application. Pulsed's mission is to make this unique laser technology commercially available to other scientists and industrial customers.

With the 'Albatross' laser, a unique system for waveform-stable single-cycle pulse generation has been developed, which is capable to deliver <10 fs at 2.2 µm and at the repetition rate of a laser oscillator. Diode-laser pumping yields ultra-low noise of field amplitude and stabilized CEP, resulting in high waveform fidelity.

'Albatross' is ideally suited to explore infrared opto-electronics at sub-cycle timescales. In addition, modular extensions for ultra-low noise external amplification, ultrabroadband mid-infrared generation and electric-field sampling will help to perform field-resolved infrared spectroscopy with highest sensitivity and reproducibility in the future. Developing a powerful spectroscopic platform and making routine blood-based health monitoring commercially available for clinical use is the long-term goal of Pulsed.

Such ambitious plans naturally require a strong team and we are very happy to have gained motivated colleagues in Philipp Rosenberger and Aleksandar Sebesta, who contribute all their experience in laser development. At this point, we would also like to express our special thanks to all our colleagues who support and advise us, such as Alexander Weigel, Nicholas Karpowicz, Mihaela Žigman, and Vladimir Pervak!

Together, we strive to further develop our ultrafast laser technology into a toolbox for a generic approach to low-cost, high-throughput molecular fingerprinting for future healthcare. If you are interested in learning more about Pulsed or joining us, we are looking forward to talking with you at any time! We are open to welcome more members of ATTOWORLD!

Merry Christmas and happy holidays, Nathalie and Nils for the whole Pulsed team.

The ALBATROSS system. Photos: Thorsten Naeser

Aleks, Nathalie, and Nils are happy to welcome Philipp in January, when he will be back from Stanford.

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a rhythm spawning at the clinics

november 28, 2022 // Ewelina Wozniak-Bauer

What does it mean to be a study nurse? In search of the answer, ATTOWORLD staff member Ewelina at the Urology department of the LMU Hospital in Großhadern, Munich, helps to gain insight here. Ewelina is part of the BIRD team, leading patient recruitment in one of our ongoing studies, sharing her experiences here.

Members of the Lasers4Life clinical study team in the LMU Medical Center in Großhadern, Munich. From left: Carola Spindler, Sabine Witzens & Ewelina Wozniak-Bauer. Photos: Thorsten Naeser

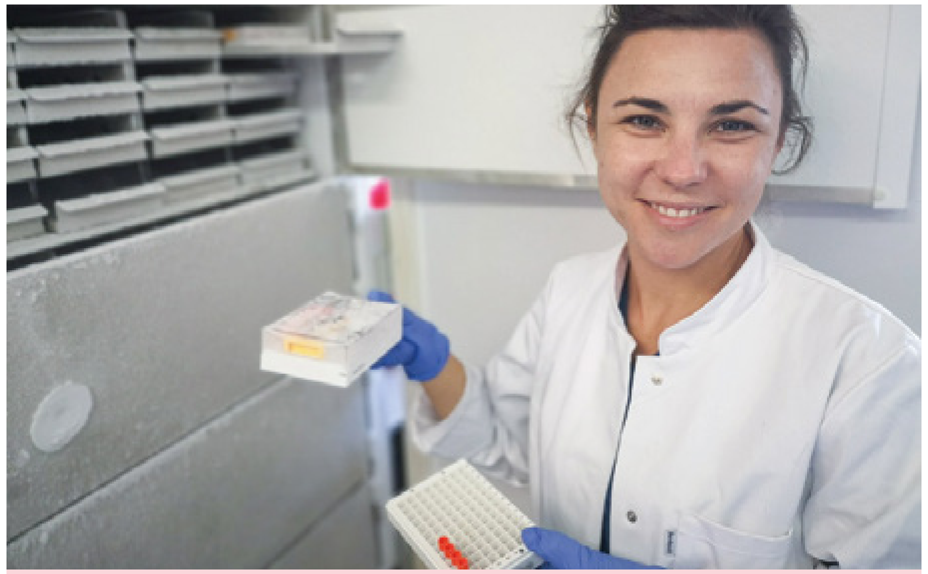
In 2022, the study *"Infrared Spectroscopy of Exprimate Urine and Blood for Prostate Cancer Detection"* took off. It aims to develop a non-invasive diagnostic test for prostate cancer diagnosis. Is such a test even feasible? The attempt is building on highly sensitive and specific laser-based field-resolved infrared spectroscopy – technology not tested for this purpose, with vast technological potential.

And what is the challenge at the clinics? At the clinic the major quest is to collect blood and urine samples from patients diagnosed with prostate cancer and different control individuals. Importantly, the samples would be of no value if not processed according to our protocols and if not accompanied by the medical data on the individuals. Screening potential patients through the hospital's internal systems is my daily routine. Once assessed, a further step is to ensure that all team members, including doctors and nurses, are aware of the daily recruitment plan.

I often observe challenges experienced by healthcare professionals, with the most prominent being time constraints and staff shortages.

team news

A difficult task, therefore, is to ensure that the recruitment occurs without disruption albeit often in the middle of hectic routine of a hospital environment. How to ensure this? Our potential patients are often feeling overwhelmed, finding themselves in an unfamiliar hospital environment. Covid-19 brought new challenges when a relative or a close friend could not accompany an anxious patient.



Study nurse Ewelina Wozniak-Bauer prepares blood samples for further testing.

Patients often share their personal stories related to the disease, hence building a personal connection with a patient is enormously rewarding and meaningful. Our patients often acknowledge the importance of this study and are proud to contribute to this project. Many expressed the misfortune of this method not being available at present time. Nonetheless, they are hopeful that participating in the study can make a difference for those diagnosed in the future, perhaps their children and grandchildren.

This is however only one side of the efforts. A large inter-disciplinary team works together to bring these clinical samples to the wet labs at the ATTOWORLD team in Garching. There, the samples get to be processed and finally measured.

Although the BIRD team is just being on their tiptoes – excitingly awaiting what the infrared molecular fingerprints will tell here – the quest is even greater. What we learned is that the success of our clinical studies lies in a joint effort of scientists and healthcare professionals who collaborate to approach the common goal. Thus, we are all proud that the first 150 patients already accepted participation and will be enabling this venture – to find new ways to catch prostate cancer. In a rhythm of the project started by the steps of a study nurse!

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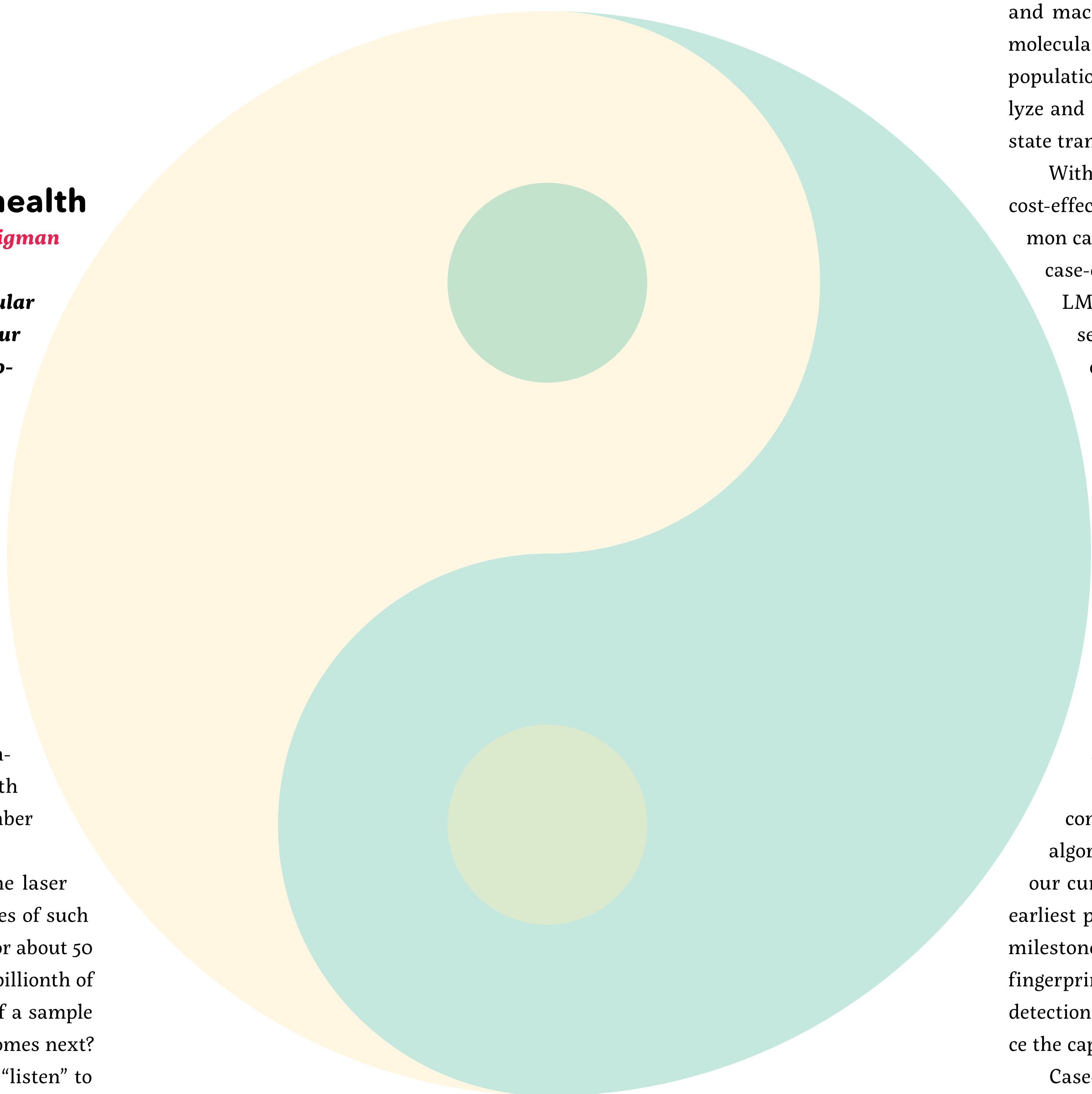
attoworld.de/bird // **lasers4life.de**



framing the Yin & Yang of human health

december 7, 2022 // Dr. Alexander Weigel & Dr. Mihaela Žigman

The function of cells in our bodies project into the molecular makeup of biomolecules in the cell-free liquid phase of our blood. Considering the hundreds of thousands of functionally diverse biomolecules, how can one simultaneously report on their quantities, when some may occur at miniscule levels? In principle, infrared spectroscopy has the capacity to do so – within just one measurement.

Thriving on developments in ultrafast light sources and precision femtosecond metrologies, we are establishing electric-field molecular fingerprinting for *in vitro* diagnostics. Here, we combine infrared lasers and field-resolved metrology into unique instruments – these break the current limitations of infrared spectroscopy: Now sensing molecules with yet new levels of sensitivity and specificity. Our technology is based on new actively stabilized and synchronized lasers with chromium-doped gain materials with unprecedented laser stability and access to a maximum number of different molecular bonds within a single measurement.

What happens within such a measurement where the laser beam is used to excite a mini droplet of a sample with pulses of such mid-infrared light? The pulses are ultrashort and last only for about 50 femtoseconds – with 1 femtosecond being one millionth of a billionth of a second. Like a gong being hit by a mallet, the molecules of a sample start vibrating when being hit by these light pulses. What comes next? We then use a special technique, electro-optic sampling, to “listen” to the response of the excitation – in our case electric fields emitted by the vibrating molecules. The recorded response is what we call a fingerprint – it is actually a pattern of measured electric field that reports on the molecules within a sample.

We bring together new ultra-broadband, low-noise infrared lasers with high-speed, high-dynamic-range field-resolved detection, and explore engineering solutions – to finally reach the long-term stability and reproducibility that are needed for large-scale human medical testing. Our goal is to devise a new minimally-invasive medical test to, on the one hand, help diagnose common cancers, and on the other hand, monitor human health, by tracking medically-relevant conditions as they develop. At the intersection of laser physics, molecular medicine and machine learning applications, we are employing electric-field molecular fingerprinting in case-control clinical studies as well as in population screening setups following individuals over time – to analyze and detect molecular changes that can be associated with health state transitions.

Within our **Lasers4Life** program we aim for a superior, time- and cost-effective platform that would help medical doctors diagnose common cancers (e.g., lung, breast, prostate, and bladder carcinoma). The case-control clinical study is run in close collaboration with several LMU clinics, already involving more than 5,000 individuals and serving as a gold standard to establish disease detection. Very encouragingly, our data show that lung, breast, prostate, and bladder carcinoma can be detected with blood-based infrared spectroscopy.

To develop a wet lab discovery into a medical test and evaluate it closer to realistic clinical case scenarios for medical applications, a two-tiered approach has been taken. On the one hand we are conducting large-scale electric-field molecular fingerprinting measurements, measuring blood-based fingerprints and teaching computational models to distinguish between different health conditions and diseases. On the other hand, the extension of the **Lasers4Life** clinical study is just in the works – aimed at involving another 20,000 individuals.

Moreover, early cancer detection is unparalleled when it comes to administering lifesaving treatments. By training our algorithms with data on early cancer stages, we wish to advance our current capabilities – such that cancer could be detected at the earliest possible stages of their etiology. Moving closer to that major milestone, we are continuously extending the catalogue of infrared fingerprint data along with parametrized medical data – to fuel better detection and distinction between different cancers and thereby advance the capacity of the developing medical test.

Case-control studies are the gold standard in disease diagnostics. At the same time, we discovered that every person has a person-specific infrared profile, based on molecules dissolved in blood. Therefore, the capacity to detect almost any medically-relevant condition will be higher if one had the possibility to self-reference the fingerprints of each person over time, detecting person-specific changes caused by disease onsets. To address this problem, in our research we set out to train computational algorithms with blood-based fingerprints and medical data of the same individuals when followed over time. Here, by spectroscopic fingerprinting of blood in the framework of the **Health4Hungary** populational study – involving already more than 7,000 individuals to be followed over the coming years – we are developing a new way for detecting the earliest transitions from healthy states to diseased ones. The development of a medical test to monitor health will greatly benefit from the information on what are the infrared fingerprints of people that have severe diagnosed diseases, such as cancer. At the same time, the health monitoring research program will help us understand the health transitions caused by aging, when our body systems inevitable change with time. Besides that, it will also help us catch early cancer conditions.

Interdisciplinary Broadband InfraRed Diagnostics (BIRD) team
Photo: Thorsten Naeser

Health and disease are like Yin & Yang: Tightly interconnected. And the capability to capture them both, along with their transitions – if possible robustly, efficiently and in a minimally invasive fashion – has the prospect to not only have the passenger seat of the future biomedical probing, but take over the position to drive these strategies.

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attoworld.de

in the mood for christmas

december 7, 2022 // Thorsten Naeser

The ATTOWORLD team let the year slowly come to an end with a successful Christmas party. This year, the guests took care of the physical well-being themselves. Delicious salads, opulent cakes and the finest Christmas cookies sweetened the nice get-together in the pre-Christmas season. They were joined by a barbecue station and a mulled wine stand on the terrace of the Max Planck Institute of Quantum Optics. The project coordinators also sponsored the drinks. Many thanks for that! Acoustic highlights at the party were also provided. Some of the participants showed their musical talent in front of the audience. Many thanks again for this great program.

Photos: Thorsten Naeser

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. Our experience and cutting-edge approach to ultrafast science is YOUR KEY to innovation and success.

UFI® world tour 2022 and new year's resolutions

october 27, 2022 // Dr. Verónica Oliver & Dr. Olga Razskazovskaya

Not another 2022 retrospective! Our prospective.

While 2022 is almost over[1] and everybody feels like sharing their success stories before wrapping it up, we want to tell you about our resolutions for the year to come.

At the trade fair LASER World of PHOTONICS Munich. Photos: Thorsten Naeser

This year gave us the chance to finally meet and catch up face to face with many of you. With about one show per month, we were present at the most relevant scientific conferences and trade fairs for the ultrafast-science and optics community around the globe. In addition to our talks and poster presentations, we completed numerous installations and campaigns at customers sites. This gave us the opportunity to do what we like the most: discuss science.

[1] We may or may not have had to write this two months in advance to help the elves with all your Christmas (orders) presents.

UltraFast Innovations was founded in 2009 with a clear vision: to make the relatively new and unexplored field of ultrafast science available to a large and diverse community. During this time, ultrafast science has done a vast leap and is now present in many research and industry laboratories around the world. In recognition of this tremendous progress, the Wolf Foundation awarded professors L'Huillier, Corkum and Krausz "for pioneering contributions to ultrafast laser science and attosecond physics" in 2022. And we went along all the way.

UFI's extreme ultraviolet (EUV) attosecond multilayer mirrors win 2022 Platinum Laser Focus World (LFW) Innovators award.

Responding to the acute needs and demands of our customers, we have established an extended portfolio that includes both a wide range of optical components and optical devices for ultrafast applications covering a broad spectral range from the IR to the XUV/soft X-ray region, as well as custom-made optics. We, thus, consider our "initial vision" fulfilled: a world where ultrafast science is widespread. So, what's next? The discussions we had this year point towards the same goal: the extreme. You are aiming for higher power, shorter pulses, shorter and even longer operating wavelengths; to push the ultimate limits. And we are here to further support you in your endeavor.

Our ongoing developments and experimental designs echo the anticipated requests of the ultrafast community, thus, ensuring our position as one of the innovators at the forefront of ultrafast science. And our impact has not gone unnoticed. For our continuous effort, we have been awarded the "Innovator of the year" for two consecutive years.

See you next year in your lab, at a conference or a trade fair. In the meantime, let's connect!

Let's keep making ultrafast science huge!

The UltraFast Innovations team.

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

mushroom controls zombie

september 23, 2022 // Thorsten Naeser

It's almost a little scary what evolutionary biologist and conservationist Roberto García-Roa of the University of Valencia caught on camera. His macro shot shows the fruiting bodies of a parasitic fungus growing out of a fly. The neuroparasite has taken up residence in the insect and infiltrated its brain. Through this brainwashing, it can direct its host to any location. The doomed insect becomes a fungus-controlled zombie.

Brandon A. Güell took his picture in the nature reserve of the Peruvian jungle of Tambopata.

Roberto García-Roa's photo won this year's competition of the scientific journal 'BMC Ecology and Evolution'. As in previous years, researchers from all over the world submitted a rich collection of images. They vividly illustrate the ecological challenges facing humanity.

Roberto García-Roa took his picture in the nature reserve of the Peruvian jungle of Tambopata. As he explains, "Spores of the so-called 'zombie' fungus (e.g., of the genus Ophiocordyceps) infect arthropods by infiltrating their exoskeleton and brain. This sounds like science fiction, but it is a reality in the animal kingdom. The infected insects migrate willy-nilly to the place where the fungus directs them. There they wait for death. Until then, the fungus feeds on its host and produces fruiting bodies full of spores. These are then shed to infect more victims."

An image submitted by Brandon A. Güell was selected as runner-up in the Research in Action category. Güell is standing hip-deep in a pond in the tropical lowland rainforest on the Osa Peninsula in Costa Rica, amid thousands of gliding tree frogs and their eggs laid on palm fronds. The biologist says: "The picture is a reminder of the first explosive breeding event I observed and photographed as part of my dissertation. The behaviours that influence the reproductive success of the adults have not been studied. The hatching of gliding tree frogs is an excellent example of high adaptability to the environment. This is because embryos can hatch prematurely to escape predators, flooding, desiccation and other dangers to the eggs."

The macro image shows how the fruiting bodies of a parasitic fungus grow out of a fly.
Photo: Roberto García-Roa

original publication:
2022 BMC ecology and evolution image competition: the winning images
Jennifer Harman et al.
***BMC Ecol Evo* 22,** 99 (2022)

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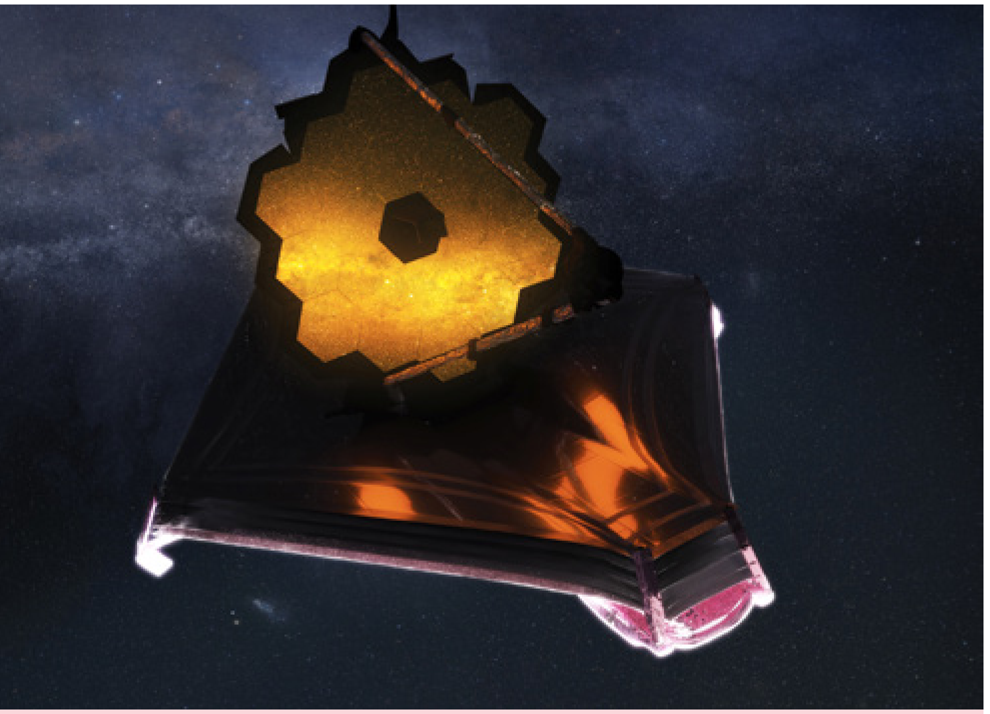
planetary molecular fingerprinting

september 27, 2022 // Dr. Nils Haag

This Christmas, astronomers celebrate a special first anniversary: One year ago, at Dec. 25th 2021, the James Webb Space Telescope (JWST) has been launched. It can be seen as successor of the Hubble Space Telescope, that for 30 years provided us with extraordinary data and pictures. But other than Hubble, JWST is not operating in the visible part of the spectrum, but in a region we, at attoworld, are quite familiar with: the Near to Mid Infrared (0,5–30 microns). Here, Nils Haag talks about the fascinating possibilities the telescope will offer astronomers by observing the universe in Infrared light.

Last time when I talked about the James Webb Space Telescope in February on our homepage photonworld.de, it just arrived at its location in 150.000.000 km distance, at which it will operate the next 20 years. After a flawless start, it had already reached some important milestones like the unfolding of the mirrors or the sun-shield. Shortly after that, the alignment of the optics followed and only weeks later, the JWST gave us some taste of its potential!



An illustration of the James Webb Space Telescope deployed in space. The telescope has a large mirror made of hexagons that are being illuminated by the galaxy being observed. Otherwise the top side of the telescope is in the dark. The underside is being lit by the sun. The telescope is set against a starry background. Artist conception of the James Webb Space Telescope.
Photo: Adriana Manrique Gutierrez, NASA Animator

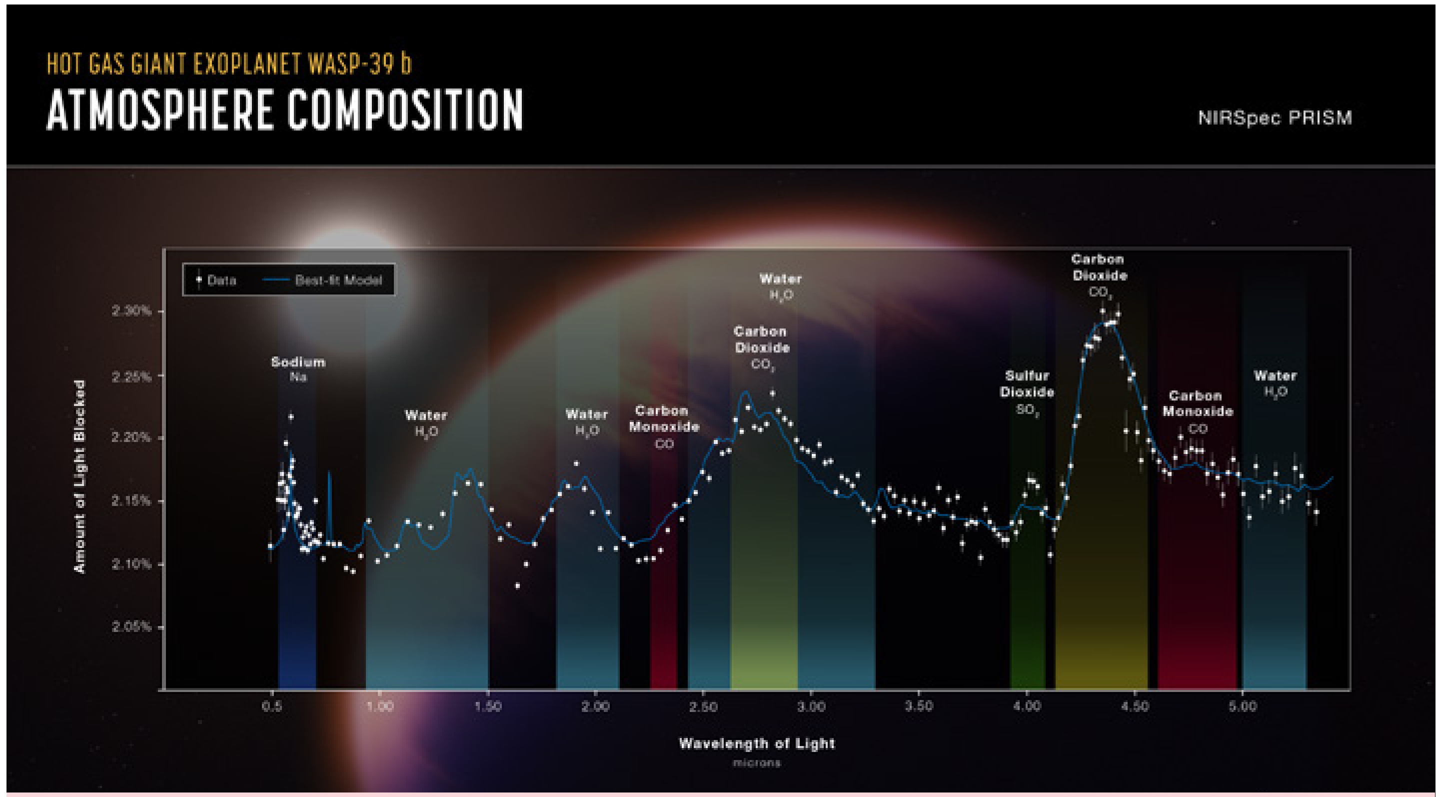
I am sure, you have seen the stunning first images published in July: The Southern Ring Nebula with its binary star system resolved in the center; Stephan's Quintet, showing the dance of galaxies in amazing detail; the breath-taking scenery of the Cosmic Cliffs in the Carina Nebula; or the first Deep-Field image showing a plethora of galaxies with higher resolution and observable redshift ever being achieved. So let's have a look on some amazing data published more recently.

Capturing the stars in infrared

At ATTOWORLD, we are very keen on investigating infrared fingerprints. And with the JWST, humanity has brought an instrument for this purpose into space!

After publishing the detection of molecular water in a gas giants atmosphere in July, the telescope has captured the infrared spectrum (0,5–5 microns) of another exoplanets atmosphere, 700 light years away from earth. This giant gas planet, named WASP-39 b, circles its star in the Virgo constellation at a distance of just about 0,05 AU, leading to an orbital period of only 4 days. An astronomical unit (AU), describes the mean radius of earth's orbit around the sun and is about 150 million km. The proximity allows to perform transmission spectroscopy of the stars light shining through the planets atmosphere, to determine the abundance of molecules and elements, e.g. carbon dioxide, water or sodium. JWST could also detect significantly more sulfur dioxide than typical for gas planets. This is a first ever proof of photo chemistry in an exoplanets atmosphere. In this process, the high-energetic light from the star dissociates water and H2 S molecules, allowing the recombination of the constituents in several steps to SO2. Our own ozone layer is formed in a similar process.

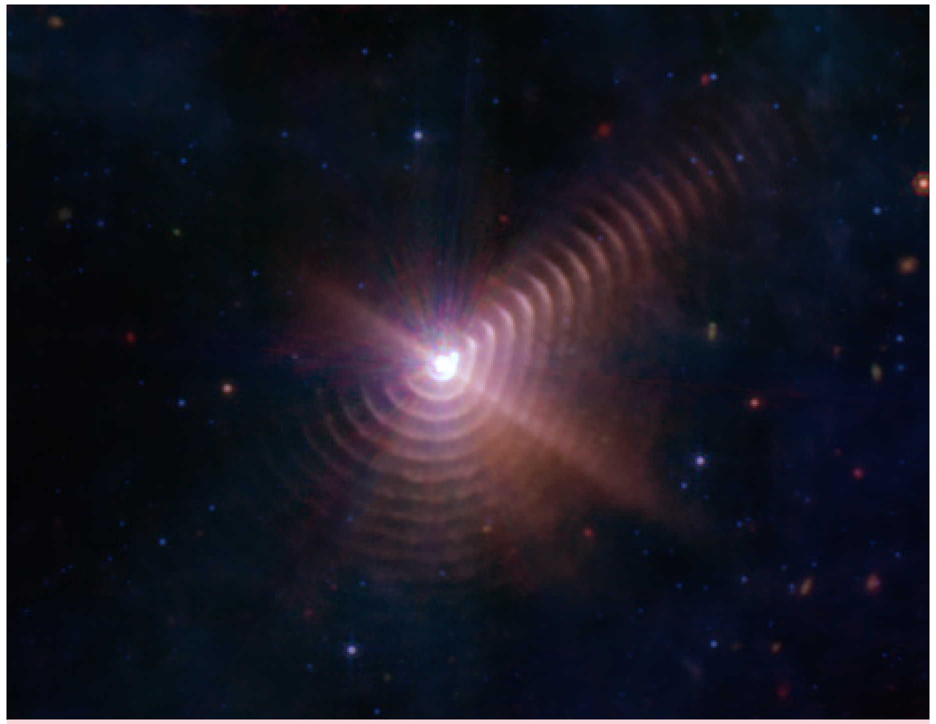
From the relative abundances of molecules in the atmosphere, astronomers can also derive, that WASP-39 b came from a region farther away from its star, but mergers and collisions with smaller planetesimals changed its path and let it grow. By looking at more and more planets, both gas and terrestrial planets, astronomers may refine their models of planet formation or even find traces of bio-markers. Obviously, the use of infrared spectroscopy is not restricted to human tissue or even material in our solar system.



Transmission spectra of the atmosphere of exoplanet WASP-39 b as recorded by the NIR spectrograph of the JWST. Credit: NASA

A celestial fingerprint

When looking for fingerprints in the universe, sometimes you can literally see them as gigantic structures in the sky.



The material ejected from the binary star system WR 140 shows a peculiar fingerprint like shape. Credit: NASA

In a distance of about 5.500 ly lies the binary star system WR 140, in which a so called Wolf-Rayet star circles a heavy star with a period of about 8 years. The orbit is highly eccentric, with a distance between the two stars ranging from about 1 to 24 AU. JWSTs MID-Infrared Instrument MIRI was able to detect a fingerprint-like structure at WR 140 resolving 17 rings, where former observations could detect only two.

This structure is most probably created by the periodic interaction of the intense stellar winds of stars, that compresses the material emitted in great quantity by such kinds of stars, leading to the formation of dusty shock waves. The slight asymmetry from the circular shape originates from the influence of radiation pressure on the dust. This image allows to study far more than 100 years of evolution of these rings and to learn how these kind of stars contribute to interstellar dust of which later new stars or planets may be born.

Watching star formation

Let's switch from the observation of fingerprints to whole fingers. The image of the Pillars of Creation is recognized as one of Hubbles highest rated pictures. It shows a part of the eagle nebula in a distance of approximately 6.500 ly from our solar system. These structures of dust and gas have a length of a few light years and a total mass of about 200 solar masses. They give us a chance to peak at the formation of young stars, some of which are only a few hundred thousand years old. But gas and dust clouds are quite opaque for visible light and even as Hubble is sensitive up to approximately 2,5 microns, its main operating region is the visible and UV. Young stars are still embedded in a pillow of gas and dust around them and these star formation regions look like heavy, compact objects in the visible – although their mean density is only about 4.000 particles per cm^3.

In the infrared, the pillars appear optically thinner and JWST can directly see the stars behind the curtain giving astrophysicist the chance to evaluate star formation models.

The Pillars of creation, recorded by the NIRCam of the James Webb Space Telescope. Credit: NASA

photonworld.de

This is only a small selection of the program and data of the JWST mission. The JWST collaboration has already published stunning photos of Neptune and Jupiter, the Orion Nebula (the closest region of massive star formation), the Tarantula Nebula (out local groups brightest and largest star formation region situated in the Large Magellanic Cloud) and many more. In addition, all of these objects have been investigated with several of the four scientific modules, revealing much more secrets than we could possibly mention in this spotlight.

If you want to learn more about the James Webb Space Telescope, its instruments, studied objects and scientific findings, I highly recommend to visit:

webbtelescope.org

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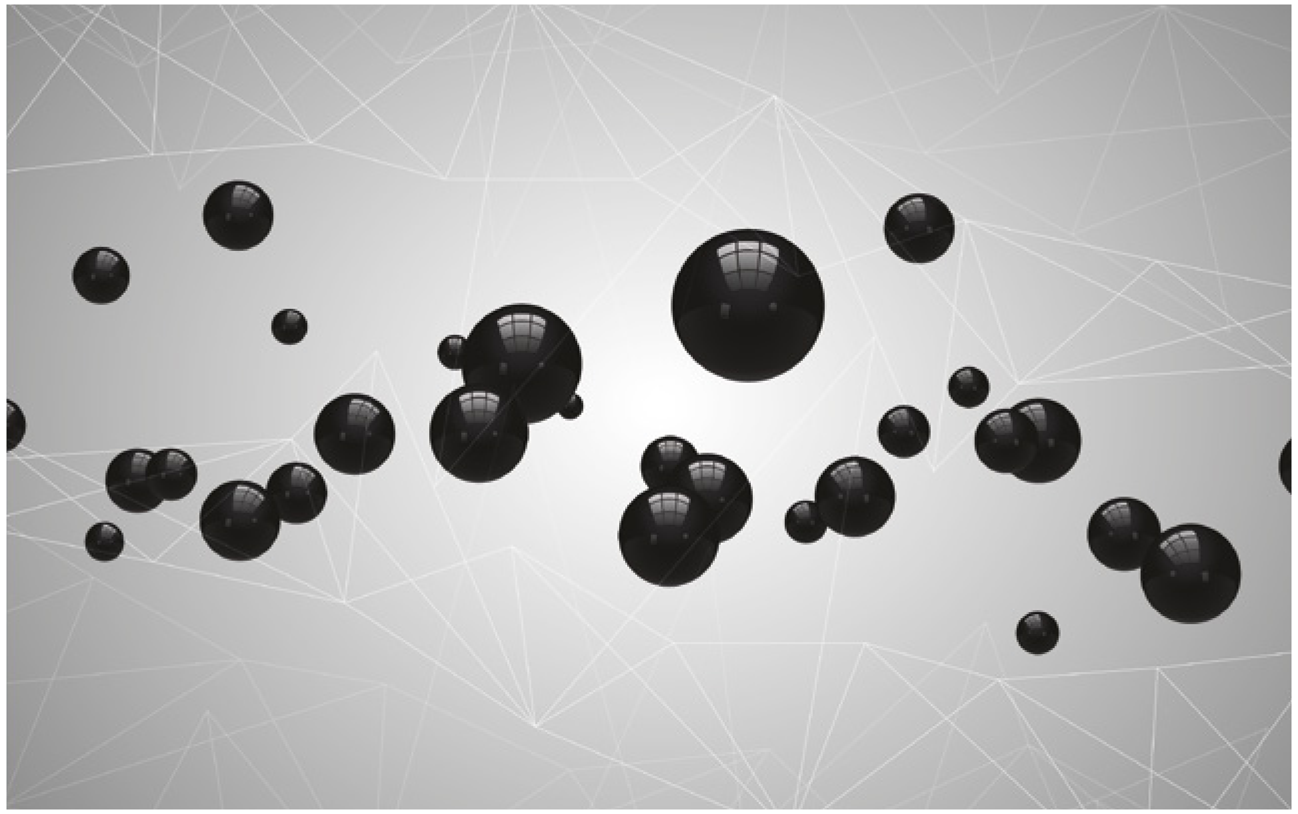
artificial scientific discovery by generative models

december 1, 2022 // Dr. Kosmas V. Kepesidis

It is by now widely-accepted that artificial intelligence (AI) has the potential to change scientific research as we know it. In fact, it is believed that a kind of a more specialized version of AI, one that mimics the scientific method, might be a goal easier to achieve than that of a general-purpose AI. This belief is based on the fact that, unlike other aspects of human life, scientific procedures are based on precise well-defined rules and logic. A particular type of artificial neural networks, known as generative models, carries the potential to achieve this goal.



Credits: www.123rf.com/free-vector

Scientific discoveries typically result from the work of human researchers by following the scientific method. It all starts with a question, the study of which typically involves a long chain of trial-and-error steps. In each of these steps, different hypotheses are created and tested. In many cases, this can be a painstakingly long process and scientists spend months or even years working on a single question without finding a satisfying answer. One of the problems is that the space of possible answers is simply too large to be systematically explored by human scientists. In fields such as drug discovery, for instance, it's believed that there are about 1063 different molecules that could be used as the basis of medical drugs [1]. Scanning all possibilities via a trial-and-error approach does not seem to be a reasonable option. Computers on the other hand have the ability to perform evaluations very fast and have been proven to be very useful in the span of the last 80 years, helping scientists automate substantial parts of their work. In traditional scientific research, along with experiments and observations, computer simulations help scientists evaluate the validity and potential of different hypo-thesesor assumptions. However, the conceptualization of the hypotheses themselves has always been exclusively a human job. It is believed that human-like traits, such as creativity and inspiration, are prerequisites for undertaking this step.

A category of AI algorithms, the so-called generative models (GMs) [2], is designed to perform a very particular type of task: to generate artificial but realistic data based on large sets of observations.For example, a GM can be trained on signals outputted by a detector and learn to produce new *artificial* events. If enough data has been used for training and the level of complexity of the model matches that of the underlying physical mechanism that produces the measured signals, these artificial events will preserve all statistical and physical characteristics of the original ones. This is achieved by trying to approximate the underlying true distribution, that summarizes the characteristics of the physical mechanism, hidden behind the real events. At a first glance, this might be mistakenly thought of as simply a different kind of computer simulation. However, the differences are striking. Simulations are based on theory and assumptions (hypotheses) about the world, while in the case of GMs, no such assumptions are required. The fact is that GMs are based solely on observations and are able to uncover an approximate distribution that fully captures the essence of a physical mechanism. This distribution can be seen as an *artificially-created hypothesis.* So, in a way, trained GMs are in fact *hypothesis-generating machines.*

The most popular and highly successful deep neural-network architectures for training GMs are the so-called generative adversarial networks (GANs) which are based on a zero-sum game between two *machine players,* a generator, who generates new artificial events, and a discriminator, who evaluates the quality of the produced samples. However, alternative approaches for creating GMs do exist. Network architectures, such as variational autoencoders or normalizing flows are some examples. GM methods have been proposed in many scientific fields for the creation of artificial scientific hypotheses. In theoretical physics, string theorists have proposed the use of GMs for making approximate predictions in the string theory landscape [3]. In experimental particle physics, researchers use GMs to create artificial particle collision events [4]. In astrophysics, GMs are used to explore the evolution of galaxies [5] and better understand dark matter [6]. In drug discovery, GANs are already being used to generate novel molecules and build a virtual molecule library [7]. And in the field of clinical medicine, researchers have experimented with GMs to be used in so-called in-silico clinical trials [8], which, in many cases, allow the dramatic acceleration in the development of new drugs and medical devices and at the same time significantly cut R&D costs.

In the future, GMs will most probably not be limited to the creation of plausible scientific hypotheses. They are expected to help with even the most fundamental step towards a scientific discovery: proposing the scientific question itself.

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R.S. Bohacek, C. McMartin & W.C. Guida (1996)
***Medicinal research reviews* 16(1)**, pp.3–50

[2] **deep learning**
I. Goodfellow, Y. Bengio & A. Courville (2016)
MIT press

[3] **statistical predictions in string theory and deep generative models**
J. Halverson & C. Long (2020)
***Fortschritte der Physik* 68(5)**, p.2000005

[4] **event generation with normalizing flows**
C. Gao, S. Höche, J. Isaacson, C. Krause & H. Schulz (2020)
***Physical Review D* 101(7)**, p.076002

[5] **exploring galaxy evolution with generative models**
K. Schawinski, M.D. Turp & C. Zhang (2018)
***Astronomy & Astrophysics* 616**, p. L16.

[6] **fast cosmic web simulations with generative adversarial networks**
A.C. Rodriguez, T. Kacprzak, A. Lucchi, A. Amara, R. Sgier, J. Fluri, T. Hofmann & A. Réfrégier (2018)
***Computational Astrophysics and Cosmology* 5(1)**, pp. 1–11.

[7] **in generative adversarial learning: architectures and applications**
Z. Zhang, F. Li, J. Guan, Z. Kong, L. Shi & S. Zhou (2022),
GANs for molecule generation in drug design and discovery (pp. 233–273)
Springer, Cham.

[8] **artificial intelligence for in silico clinical trials: a review**
Z. Wang, C. Gao, L.M. Glass, & J. Sun (2022)
arXiv preprint, arXiv:2209.09023

Photo: Thorsten Naeser

breakthrough of the year for 2022

december 9, 2022 // Thorsten Naeser

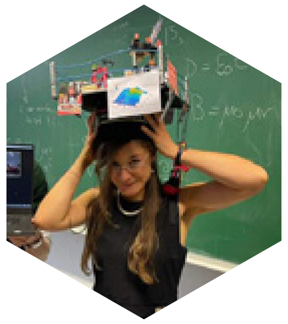
The *physicsworld* magazine has chosen the recent research of the team around Dr. Martin Schultze and Dr. Marcus Ossiander as one of the top ten breakthroughs of 2022. With their paper "The speed limit of optoelectronics" published in March 2022, they have explored the limits of optoelectronic circuits.

The team at the Max Planck Institute of Quantum Optics used laser pulses lasting just one femtosecond to switch a sample of a dielectric material from an insulating to a conducting state at the speed needed to realize a switch that operates 1,000 trillion times a second (one petahertz). "Although the Apartment-sized apparatus required to drive this super-fast switch means it will not appear in practical devices any time soon, the results imply a fundamental limit for classical signal processing and suggest that petahertz solid-state optoelectronics is, in principle feasible", says Hamish Johnston, editor at *physicsworld.*

More information: **physicsworld.com/a/physics-world-reveals-its-top-10-breakthroughs-of-the-year-for-2022**

original publication:
the speed limit of optoelectronics
M. Ossiander, K. Golyari, K. Scharl, L. Lehnert, F. Siegrist, J.P. Bürger, D. Zimin, J.A. Gessner, M. Weidman, I. Floss, V. Smejkal, S. Donsa, C. Lemell, F. Libisch, N. Karpowicz, J. Burgdörfer, F. Krausz, M. Schultze
***Nature Communications* 13**, 1620 (2022)

congratulations to Dr. Julia Gessner



september 20, 2021 // attosecond spectroscopy 2.0

Julia Gessner has defended her doctoral thesis titled: **“Strong-field driven charge and spin dynamics in solids”**. We congratulate warmly on passing successfully the exam.

congratulations to Dr. Johannes Schötz

september 29, 2021 // field-resolved nano spectroscopy

Johannes Schötz has defended his doctoral thesis titled: **“Field-resolved measurements of ultrafast light-matter interaction”**. We congratulate warmly on passing successfully the exam.

congratulations to Dr. Gaia Barbiero

september 30, 2021 // field-resolved nano spectroscopy

Gaia Barbiero has defended her doctoral thesis titled: **“Efficient nonlinear compression of a high-power Yb:YAG oscillator to the sub-10 fs regime and its applications”**. We congratulate warmly on passing successfully the exam.

congratulations to Dr. Kathrin Mohler

october 14, 2021 // atomic & electronic motion in 4d

Kathrin Mohler has defended her doctoral thesis titled: **"Investigating ultrafast light-matter interactions via dual-comb Raman spectroscopy and electron diffraction of nanophotonic waveforms"**. We congratulate warmly on passing successfully the exam.

congratulations to Dr. Dmitry Zimin

october 7, 2021 // attosecond spectroscopy 2.0

Dmitry Zimin has defended his doctoral thesis titled: **“Petahertz optoelectronics via attosecond control of solids”.** We congratulate warmly on passing successfully the exam.

PhD hat by Dr. Keyhan Golyari. Photos: Thorsten Naeser

congratulations to Dr. Yu Chen

december 9, 2021 // advanced multilayer optics

Yu Chen has defended his doctoral thesis titled: **“Development of ion beam sputtering for multilayer dispersive mirrors”**. We congratulate warmly on passing successfully the exam.

congratulations to Dr. Sebastian Gröbmeyer

march 18, 2022 // cmf laser science

Sebastian Gröbmeyer has defended his doctoral thesis titled: **“High-Power Few-Cycle Pulse Generation Towards the Gigawatt Frontier”**. We congratulate warmly on passing successfully the exam.

congratulations to Dr. Keyhan Golyari

march 22, 2022 // attosecond spectroscopy 2.0

Keyhan Golyari has defended his doctoral thesis titled: **“Linear Petahertz Photo-Conductive Switching”**. We congratulate warmly on passing successfully the exam.

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 and FOR 2783 and is visited by about 2000 interested students per year.

follow Alice into quantum world! PhotonLab's audio play for young, old or in-between

november 24, 2022 // Dr. Veit Ziegelmaier

Live reading of the audio play "Alice im Quantenland" ("Alice in Quantum Land") at the "Türen auf mit der Maus" ("Doors Open with the Mouse") day / October 3 Max Planck Institute of Quantum Optics. Photo: Katharina Jarrah / MPQ

With its audio play "Alice im Quantenland" ("Alice in Quantum Land"), the PhotonLab student laboratory at the Max Planck Institute of Quantum Optics (MPQ) now offers elementary school pupils and older an entertaining and informative way of learning about the phenomena of quantum physics. The first episode of the multi-part series in German language is entitled "Eine Katze namens Schrödinger" ("A cat named Schrödinger"). Together with the title song "Welt der Quanten" ("World of Quanta") the episode is available for listening on all major streaming portals. Further sequels are currently in the making.

The cover of our first episode, which is now available for listening on all common streaming platforms Illustration: Andi Papelitzky

Quantum physics for 6–12 year olds – is that possible? Of course it is!

For more than 10 years now, the PhotonLab student laboratory at the Max Planck Institute of Quantum Optics has been attracting school classes to its facilities for individual experiments with the phenomenon of light. And the response is great, as evidenced not only by the number of a good 2,000 students per year, but also by various practical courses offered and the profound support provided at international physics competitions for the youth. However, in order to get school beginners – and thus the researchers of tomorrow – excited about the physics of light at an early stage, a special educational program has now been devised for children that turns the "crazy" phenomena of quantum physics into exciting adventures and unusual encounters.

In cooperation with ATTOWORLD's communications department and the Cluster of Excellence MCQST (Munich Center for Quantum Science and Technology), PhotonLab has now produced "Alice im Quantenland«, ("Alice in Quantum Land") a German language audio play that presents the basic phenomena of quantum physics in a child-friendly and playful manner. Based on the famous story "Alice in Wonderland" by Lewis Carroll, the eponymous heroine experiences equally wondrous events, but this time in the Quantum World, which, however, are not imagined or dreamed of, but are actually a part of reality in the smallest constituents of our world.

Let the adventure begin!

In the pilot, Alice and her namesake pet Rabbit miraculously end up in Quantum World, where the laws of nature are very different from what she and the listeners are used to. In this first episode, entitled "Eine Katze namens Schrödiger" ("A Cat Named Schrödinger"), Alice experiences a great deal of adventure in her search for Rabbit, whom she can't find there right away. First, after a few attempts, she suddenly manages to reappear on the other side of a wall that blocks her further way. Later on, Alice frees a mysterious talking cat named Schrödinger from a box. The cat claims that it was dead and alive at the same time in this crate. All sorts of things! Schrödinger becomes Alice's companion and friend on her journey through the Quantum World. You can listen to the whole episode on all usual streaming portals as well as the institute's own websites and youtube-channels.

Alice and Schrödinger's cat as guests of the famous mouse from WDR. Graphic: WDR, Andi Papelitzky, Dennis J.K.H. Luck

Alice alive!

But Alice and Schrödinger's adventures could also be experienced live at various science events for children and young people in Munich this summer and fall. Here, Sofie Silbermann and Veit Ziegelmaier, as speakers of the play, slipped into their roles in front of numerous audiences. The premiere took place in May at the youth fair "forscha" of the Munich Science Days at the Alte Messe. This was followed at the end of July by another performance at Deutsches Museum as part of the "Festival der Zukunft" ("Festival of the Future"). On October 3, Alice and Schrödinger had a home game during the "Türen auf mit der Maus" day ("Open house with the Mouse") at the Max Planck Institute of Quantum Optics, where they were able to join the host, the famous Mouse from the WDR program.

The voices of Alice and Schrödinger: Sofie Silbermann & Veit Ziegelmaier in the recording studio. Photo: Veit Ziegelmaier

Alice, Einstein and quantum soccer

Currently, episode 2 is being produced, but the framework and the phenomena to be discussed in the further sequels have already been sketched out. In the second sequel – attention: spoiler! – Alice and Rabbit actually meet the probably most famous physicist of all times Albert Einstein, who actually talks to them with his original voice on the basis of archive recordings and can give a decisive hint about the whereabouts of Rabbit. Finally, Alice and Schrödinger arrive at the venue of a soccer match. But here in the Quantum World other rules are played with, the places where the balls actually hit the goal, follow interferential patterns as they are known from waves. And so, mysteriously, goals are scored where the defense of the opposing team doesn't expect a ball. In addition, the audience always has to look away at the decisive moment (if it weren't for Rabbit on the pitch, who briefly disrupts the game). The whole thing is pretty weird! But the physically trained already suspect it: Nothing else happens in the double-slit experiment, the probably generally most well-known experiment of quantum physics. Further phenomena like the superposition will be treated in the coming sequels. And who knows, maybe Alice and Schrödinger will mysteriously find their way to the experimental laboratory at the Max Planck Institute of Quantum Optics? That's all we can reveal at this point.

Behind the scenes

But how does such an episode actually come into being? At the beginning there is a committee consisting of physicists, which is chaired by Dr. Silke Stähler-Schöpf, the head of the PhotonLab together with Dr. Tatjana Wilk (General Manager of MCQST). Here they eagerly discuss which quantum physical phenomena should be covered in the audio play and how they can be simplified into talking pictures to make an exciting story. With this common thread, the basic structure of an episode then emerges. These ideas are then implemented in a script by Dr. Veit Ziegelmaier from the ATTOWORLD communications team: Here the story becomes dramaturgically embellished, the dialogues develop and a suitable song to the topic comes into being. The original version of the script is sent back to the scientific advisory board, which checks the content for accuracy and comprehensibility anew. Once the script has been finalized, Sofie Silbermann, a member of the PhotonLab staff, and Veit Ziegelmaier go into the audio studio to record and sing their parts. And then the actual main work begins for Ziegelmaier as producer, whereby the humanities graduate benefits here from his training as a speaker and his theater experience. The recordings are edited and put together to form a coherent whole. Effects and music are selected to create an exciting atmosphere. Finally, the resulting audio tracks undergo mixing and mastering. Then is the episode finished and ready for release.

Special thanks to our scientific board, namely to Berit Körbitzer, Linda Qerimi, Silke-Stähler Schöpf, Karan Tiwana and Tatjana Wilk as well as to our cooperation partners, the Ludwig-Maximilians-Universität München (LMU), the Munich-Center for Quantum Science and Technology (MCQST), the Deutsches Museum and the Munich Quantum Valley (MQV).

More information about the PhotonLab:
www.photonworld.de/photonlab

Attosecond Science Laboratory@KSU, Riyadh

Our isolated attosecond pulses of extreme ultraviolet light coming in synchronism with controlled few-cycle near-infrared laser waveforms are being used to explore the ultrafast response of emerging materials, such as two-dimensional (2D) materials and organic semiconductors under intense light-field excitations for the development of novel ultrafast optoelectronic devices. Novel sources of high-order harmonics based on organic semiconductor thin films are also investigated.

developing the KSU/attoworld-collaboration in broader areas

november 30, 2022 // Prof. Abdallah Azzeer

The newest collaboration research activities in 2021 between King Saud University (KSU), represented by Prof. Abdallah Azzeer and the ATTOWORLD team, represented by Prof. Matthias Kling, are aimed to further develop the already existing collaboration since 2008 in broader areas. This includes the emerging semiconducting materials and their optical and optoelectronics application through the study of organic semiconductor materials by observing their high order harmonic generation behavior under intense near infrared ultrashort laser pulses. A PhD student of King Saud University spent two months working in the Kling group to perform parts of this project.

Another area is focusing on the improvement of Transient field-resolved (TFR) mid-IR reflectometry for studying ultrafast electronic dynamics in two-dimension materials. A unique systematic study has been conducted to connect the microscopic electron dynamic to the macroscopic current signal induced on the electrodes. These research studies have been published in different journals.

Another area is focusing on the improvement of Transient field-resolved (TFR) mid-IR reflectometry for studying ultrafast electronic dynamics in two-dimension materials. Photo: Abdallah M. Azzeer

The newest collaboration research activitie are including the emerging semiconducting materials and their optical and optoelectronics application through the study of organic semiconductor materials by observing their high order harmonic generation behavior under intense near infrared ultrashort laser pulses. Photo: Ahmad Saleh

original publication:

fifth-order nonlinear optical response of Alq3 thin films
Ahmad Saleh, Weiwei Li, Hadi AL Qahtani, Marcel Neuhaus, Ali Alshehri, Boris Bergues, Meshaal Alharbi, Matthias Kling, Abdallah Azzeer, Zilong Wang, Abdullah F. Alharbi
***Results in Physics* 37,** 105513 (2022)

the emergence of macroscopic currents in photoconductive sampling of optical fields
Johannes Schötz, Ancyline Maliakkal, Johannes Blöchl, Dmitry Zimin, Zilong Wang, Philipp Rosenberger, Meshaal Alharbi, Abdallah M. Azzeer, Matthiew Weidman, Vladislav Yakovlev, Boris Bergues, Matthias Kling
***Nature communications* 13,** 962 (2022)

transient field-resolved reflectometry at 50–100 THz
Marcel Neuhaus, Johannes Schötz, Mario Aulich, Anchit Srivastava, Džiugas Kimbaras, Valerie Smejkal, Vladimir Pervak, Meshaal Alharbi, Abdallah M. Azzeer, Florian Libisch, Christoph Lemell, Joachim Burgdörfer, Zilong Wang, Matthias Kling
***Optica* 9,** 42–49 (2022)

The KSU and MPQ/LMU teams (BIRD) for the "Early Cancer Detection with Lasers" (ECDL) had a meeting on June 20, 2021 to discuss the latest results of the project. Photo: Thorsten Naeser

At the crossroads of laser physics, molecular biosciences and cancer medicine our research program aims at developing and validating a novel femtosecond-laser-based molecular spectroscopic fingerprinting as a robust new analytical method for early cancer detection. In this context our group with the focus "medicine" at KSU, under the leadership of Prof. Nabholtz, Prof. Alsaleh & Prof. Azzeer, in collaboration with MPQ/LMU and the ICR Group is developing two clinical research strategies:

1. Early detection of cancer on liquid biopsies:

several proof-of-concept studies performed (Saudi Arabia, Algeria, United Arab Emirates), of which two completed (breast/colon cancers) and five ongoing (pancreas, stomach, lung, ovary and prostate cancers). A large-scale validation trial (breast cancer) is ongoing in France (collaboration with Sorbonne University and French Federation of Cancer Centers).

2. Individual upfront prediction of cancer medications efficacy on liquid biopsies:

led to a partnership with Pfizer: trial evaluating the combination Aromatase Inhibitor + CDK 4/6 Inhibitor Palbociclib.

The KSU and MPQ/LMU teams have met again in Garching on September 26, 2022. Photo: Abdallah M. Azzeer

A German delegation of Bavarian Industry Association (vbw) and German-Arab Friendship Association (DAFG) headed by Prof. Otto Wiesheu, President of the German-Arab Friendship Association was welcomed by H.E. President of KSU on November 1, 2022. The delegation included Prof. Alexander Radwan Member of the German Bundestag, Prof. Kai-Olaf Hinrichsen from Technical University of Munich, Houssam Maarouf, Vice President of the German-Arab Friendship Association and Dieter Lamlé German Ambassador to Saudi Arabia. The director of ASL emphasizes the fruitful collaboration between KSU, LMU and MPQ. Photo: KSU press dept.

original publication:

breast-cancer detection using blood-based infrared molecular fingerprints

Kosmas V. Kepesidis, Masa Bozic, Marinus Huber, Nashwa Abdel-Aziz, Sharif Kullab, Ahmed Abdelwarith, Abdulrahman Al Diab, Mohammed Al Ghamdi, Muath Abu Hilal, M.R. Kailash Bahadoor, Abhishake Sharma, Farida Dabouz, Maria Arafah, Abdallah M. Azzeer, Ferenc Krausz, Khalid Alsaleh, Mihaela Žigman, Jean-Marc Nabholtz

***BMC Cancer* 21,** 1287 (2021)

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“I am pretty fast when I paint”

[Niklas Elmehed]

october 4, 2022 // Thorsten Naeser

Niklas Elmehed is one of the first to know who gets a Nobel Prize. He absolutely has to. Because the Swedish artist draws the laureates for the official portraits that are published at the same time as the announcement. In this interview, he talks about his unmistakable portraits, which are shared by millions of people and media channels around the world.

How much time in advance do you know the names of the Nobel Laureates?

This is the most common question I receive but unfortunately I can’t tell you exactly how long time I get due to the secrecy from the Nobel Prize. But I am pretty fast when I paint and finalize a portrait in a few hours.

Why do they not use photographs?

Initially an art director with the Nobel group realized that “to present the winners using photos was very tricky”. As they could not be informed ahead of the announcement, fresh photography was not possible. Existing photos had copyright issues, as well as the problem of poor quality images for the less famous winners. I got the job of developing a graphic style that would become a brand, and give great impact to the revelation of the winners. I work a lot with their eyes. It’s as though they are looking directly at the viewer. The concept behind it is to have that ’breaking news’ feeling. When people see these images, they immediately associate them with the Nobel Prize announcements.

Why did you choose this style?

The graphical concept behind the portraits is to give the portraits the expression of breaking news – a strong and unique visual impression. 2017 the Nobel Prize went through a graphical makeover and it was decided that the main color for the announcements would be gold, preferably gold with texture not just a representational color. I was asked to adjust my blue and yellow paintings, which was the look 2014–2017, to the new golden look. I experimented a lot with different gold paint and fell for the gold foil, a super thin metal foil that you can put on the painting with a special glue. Together with black

outlines, painted on a white background I think the portraits has a very strong and exclusive impact.

What year did you start to portrait the Laureates?

I was hired as the art director of Nobel Media and responsible for all visual content during the announcements 2012. This year I made my first quick portrait sketches with a black marker and the reason was that I couldn’t find photos of some of the Laureates to publish on Nobel Prize’s official digital platforms. Some of the sketches where picked up and used by big news media and 2014 I got the job to create a visual style for the official portraits. I came up with the idea of black outlines together with blue and yellow shadows and highlights.

Did any Laureate show excitement or frustration about their portraits?

Actually I have never received any feedback from the Laureates. I guess they are too busy the time after they have been awarded the Nobel Prize.

What do you work with when you are not drawing portraits of the Nobel Laureates?

I work most of my time with my art in several projects. The rest of the time I create visual content for other clients than the Nobel Prize. For example, I do some motion graphics design for the Swedish National Football Team.

Any person you want to draw a portrait as a Nobel Laureate?

Yes, I have some people that I would love to portrait as a Nobel Laureate but I can’t tell you that. If I did so, people would start to speculate if I have any inside information about upcoming candidates.

More information about Niklas Elmehed:
niklaselmehed.com

the blackest black

december 2, 2022 // Dr. Veit Ziegelmaier

Developments in art, science and technology are often closely intertwined and influence each other. In this respect, it also seems no coincidence that the development of abstraction in art at the beginning of the 20th century was accompanied by ground-breaking innovations in the natural sciences that turned the previously familiar view of the world upside down. Einstein's theory of relativity and the findings in the field of quantum mechanics revealed a contradiction between reality and appearance, and the parallel pioneering achievements in the field of aviation also allowed people to view the world from above for the first time. From a bird's eye view, fields, forests and stretches of land became coloured squares in the plane.

1

One of the most radical abstract positions at the beginning of the last century was pursued by the painter and art theorist Kazimir Malevich (1879–1935) with his "Black Square," which has become an icon today and was exhibited for the first time in 1915. Even nowadays, some with a conservative understanding of art may shake their heads at this. But what Malevich actually did was nothing less than to usher in with a bang the birth of total abstraction, reducing form and colour to the purely essential. And with that, in the same breath, he also seemed to herald its end: For what could be more radical in this respect after a black square?

Malevich's square was surrounded by a contrasting white space; it floated, if you will, in a vacuum. Many years later in the 1950s, the French artist Yves Klein (1928–1962) nevertheless attempted to go a step further with his monochrome, edge-grazing canvases. His all-over paintings celebrated the surface and eradicated the contour-defining frame of form in the picture. In other words, form is now also completely dissolved here in favour of the pure effective power of colour. The paintings were to be understood only as an "accidental" section of a basically endless state that continues in the viewer's imagination over the image surface. Just like when we look into the night sky, and thereby see a section of the unimaginable infinity of the universe. Klein also wanted to revolutionize and dissolve the act of actually generating images through painter's tools such as the brush, and through the painterly interpretation of forms as an image of nature, which had been valid for thousands of years. In his "Anthropometric" paintings from the mid-1950s, he had a female model, whose naked body he covered with blue paint, loll on a white paper so that an image in the sense of a direct impression was created without the aid of brushes. Head and arm parts remain largely left out, so that the resulting forms on the surface appear like the "x" – shaped appearance of chromosomes, those biological cell structures that contain our individual gene code. In them our appearance and our being is defined on a molecular level. Only later does this become apparent in the appearance accessible to our senses, namely in our shape, the colour of our skin, eyes and hair, and our character traits. That Yves Klein wanted to reproduce the image of a human being not only in its external form, but also with reference to its biological information content in the chromosomes, seems obvious. For the word "chromosome," which comes from the Greek, reads like a description of the work. It means nothing other than "coloured body," a term that biology once chose for its research because of the good stainability of these structures.

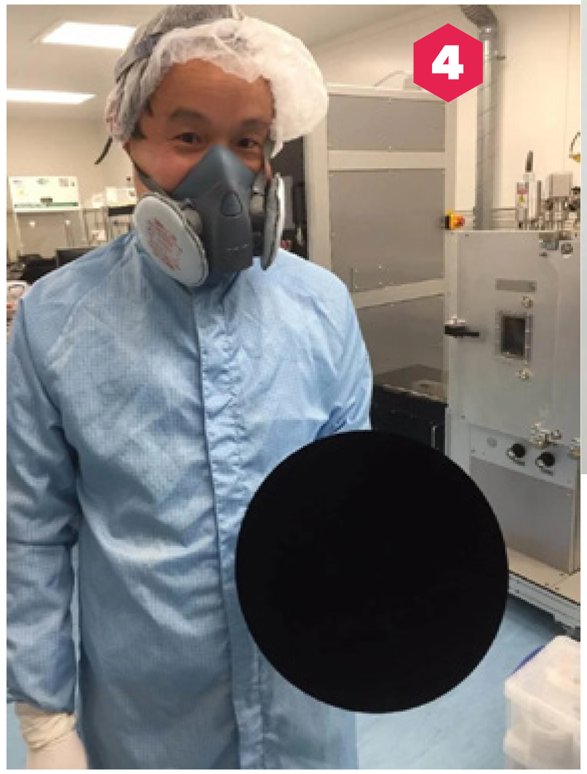
2

Yves Klein is associated with the colour "blue" like hardly any other artist. In his monochrome paintings described above, he used a special, slightly reddish ultramarine blue, which is characterized by a hitherto undreamed-of depth of colour and luminosity. The artist experimented for a long time with colour pigments and various binders to achieve this effect. In 1960, he even patented this shade of blue under the name "International Klein Blue (I.K.B.)". But can an artist actually legally secure a colour as a unique selling point?

This controversy was to be hotly debated again decades later. While in Yves Klein's case it was merely a certain shade of blue that he developed and claimed for himself, the celebrated and knighted

3

British-Indian contemporary artist Anish Kapoor (*1954) caused some kind of a scandal in the art world. In 2016, he not only secured the blackest black in the world for himself, but also a special technical process for exclusive use in the art world, which he himself did not even develop. We are talking about "Vantablack," an acronym for Vertically Aligned Nanon Tube Array. This is a substance made of aligned carbon nanotubes that are 300 times as high as they are wide. Incident light is virtually no longer reflected, as it is absorbed 99.965% of the time. Vantablack was developed in 2014 by U.K.-based Surrey Nano Systems for metrology, aerospace and military applications. Kapoor, who has repeatedly experimented artistically with the dematerialization of material and space in his predominantly sculptural works, immediately recognized the potential of the substance for the field of art.



Kapoor's artistic endeavour is, among other things, to visualize black holes as they are described in astronomy. A black nothingness with a tremendous suction force that cannot be grasped spatially at all. It seems as if he wanted to combine Malevich's basic black form with the pictorial depth of Yves Klein's colour depth effect. Even an early work entitled "Descent into Limbo" from 1992 illustrates this. It is a round depression in the floor, the walls of which were painted completely black to create the impression of absolute emptiness. And indeed, years later, at a 2018 exhibition in the Portuguese city of Porto, this work actually "swallowed" a visitor. A viewer actually thought it was an optical illusion and plopped into the supposed void, injuring himself. With the use of Vantablack, which did not exist when the work was originally created, this would not have happened. The material creates the impression of total flatness simply by virtue of its absorptive power.

Kapoor's solo attempt to use Vantablack exclusively drew the attention of a number of artists who strongly criticized his approach. One of them is the British artist Stuart Semple, far less well-known than Kapoor, but who launched a sustained all-out attack. In 2016, Semple developed an extremely intense shade of pink, which he called "The pinkest pink" in reference to the makers of Vantablack, and offered it for purchase and use through his artist website – except for one: Anish Kapoor. Kapoor's response was not lacking. He got hold of a can of paint in a roundabout way, stuck a finger into the pigment, as if to test the quality, and took a photo of it, which he then posted on his social media channels. His message was clear, as it was his extended middle finger! But it sparked Semple again, and he went on to develop his own versions using the light-absorbing power of Vantablack in pigment form with an appropriate acrylic-based binder. In the course of their development, he named

them "Better Black", "Black 2.0" and "Black 3.0". Even if, according to Semple's own statement, their implementation was not quite perfect, they are at least more than significantly cheaper to produce and to purchase. Anish Kapoor was admittedly blocked again for the product.

But even without Stuart Semple's active involvement, Kapoor no longer owns "the blackest black". And that' not because he canceled his deal with the company Surrey Nano Systems. Back in 2015, "Dark Chameleon Dimers" from the King Abdulla University of Science and Technology in Saudi Arabia saw the light of day, an even more light-absorbing black. Considered to be the darkest man-made substance, the material consists of gold nanoparticles of different shapes bonded together; more specifically, a nanosphere about 50 nm in diameter is attached to a nanorod about 100 nm long. A special combination, that gives the material these exceptional absorption properties. As a result, "Dark Chameleon Dimers" still holds the entry for the blackest black in the Guinness Book of Records.

Sometimes it is not only theories and findings from science that influence the content of art. Applications based on scientific research can also help determine the possibilities for creating art. And sometimes another causal relationship comes true in the form of a proverb. Referring to Kapoor and the museum visitor in Porto, one would like to say: "He who digs a pit for others, falls into it himself".

image 1: ***Black Suprematic Square (Black Square), 1915***
Kasimir Malevich (1879–1935) // Oil on canvas // 79,5 × 79,5 cm
Tretyakov Gallery // © Tretyakov Gallery

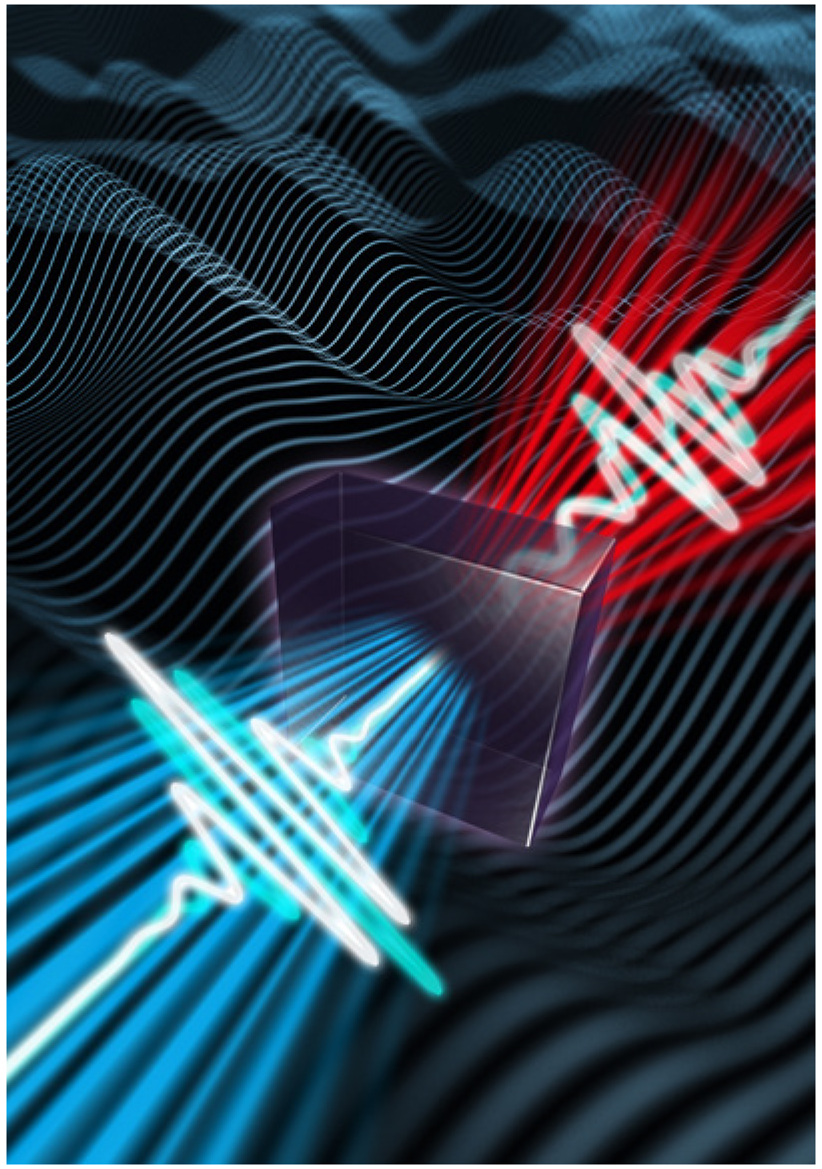
image 2: ***Monochrome bleu sans titre, 1956***
Yves Klein (1928–1962)
Pure pigment and synthetic resin, very fine cotton canvas mounted on chipboard
50 × 50 cm
© Succession Yves Klein c/o ADAGP, Paris

image 3: ***Anthropométrie sans titre, 1960***
Yves Klein (1928–1962)
Pure pigment and synthetic resin on paper mounted on canvas // 145 × 298 cm
Hirshhorn Museum and Sculpture Garden
© Succession Yves Klein c/o ADAGP, Paris

image 4: ***A Surrey NanoSystems technician demonstrating a three-dimensional bowl-shaped object spray-coated with the new paint, 2017***
Image courtesy Surrey NanoSystem

image 5: ***Concrete and pigment, 1992***
Anish Kapoor (*1954) // 600 × 600 × 600 cm
Documenta IX Kassel, 1992 // Serralves, Porto, 2018
via the artist's website

image 6: ***A photo of 'the pinkest pink,' 2016***
Stuart Semple (*1980)
via Anish Kapoor's Instagram page



The cover of this year's issue of our *pulse* magazine illustrates the research on the paper "Single-cycle infrared waveform control". The artwork shows ultrashort laser pulses sent into a nonlinear crystal and undergo complex frequency-mixing processes. By adjusting the laser input parameters, the ATTOWORLD scientists were able to precisely control the oscillations of the generated mid-infrared light.

Illustration: Dennis J.K.H. Luck & Alexander Gelin

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single-cycle infrared waveform control
Philipp Steinleitner, Nathalie Nagl, Maciej Kowalczyk, Jinwei Zhang, Vladimir Pervak, Christina Hofer, Arkadiusz Hudzikowski, Jarosław Sotor, Alexander Weigel, Ferenc Krausz, Ka Fai Mak
***Nature Photonics* 16**, 512 (2022)

tragedy for the sons

Thorsten Naeser

Steffen Schroeder puts himself in the minds of Max Planck, Albert Einstein and their sons Erwin and Eduard. He recounts personal and poignant events from their lives at the end of the Second World War.

These were dark times that Max Planck had to endure in 1944. Shortly after the failed assassination attempt on Adolf Hitler on 20 July, his son Erwin was arrested. He was accused of being a co-conspirator in the attack. Erwin Planck was indeed involved in the attempted coup that would have saved so many lives. What this meant was clear: a death sentence that only had to be confirmed by a mock trial. Max Planck was threatened with the fate of losing his last child.

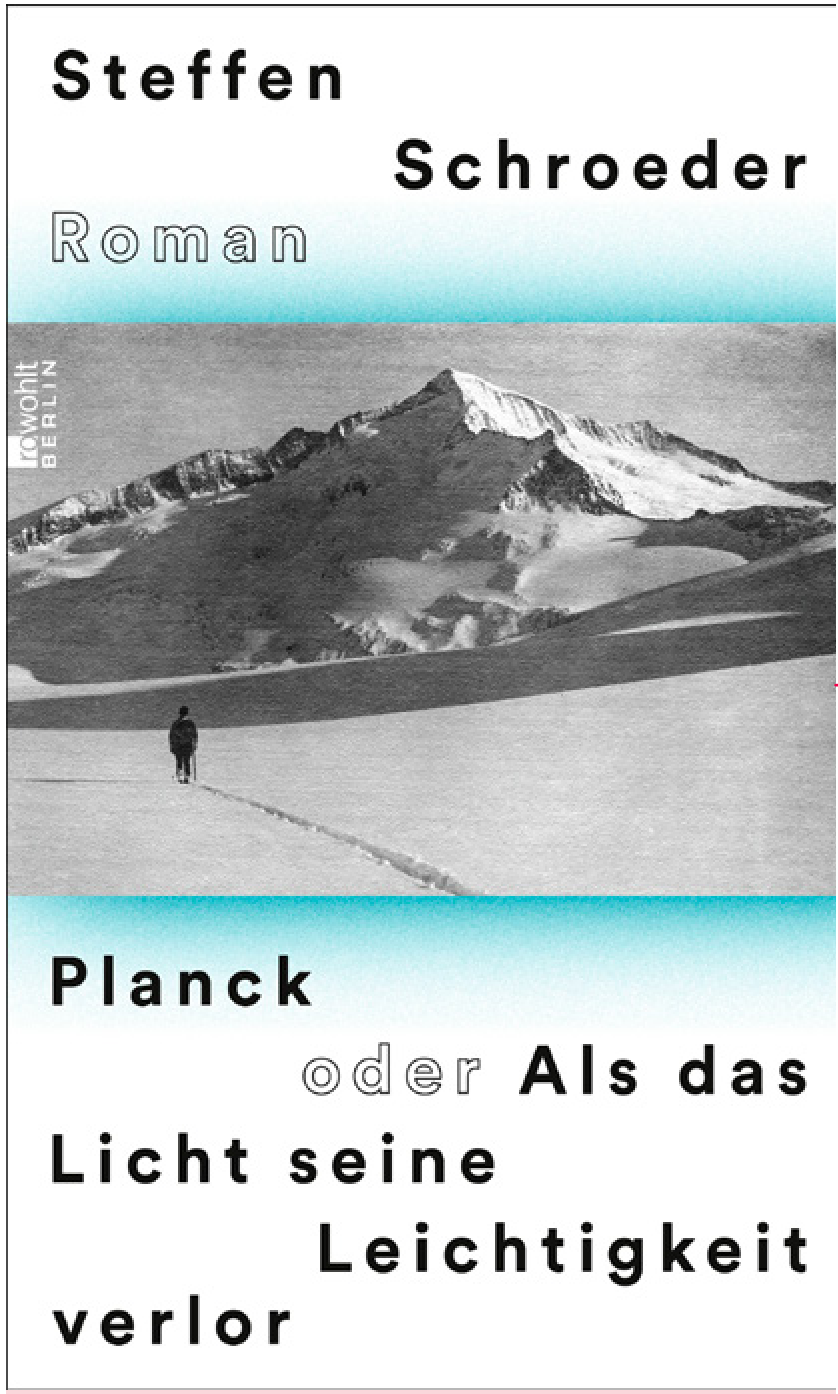
And it was to get even worse for the 87-year-old: When his son Erwin had long been in prison awaiting trial, a letter from the Reich Chamber of Culture had been on the founder of quantum physics' desk for weeks. In it, its president asked the researcher to unconditionally declare his allegiance to the Führer in an article for a brochure. Max Planck was at a loss and in despair.

The author Steffen Schroeder puts himself in this hopeless situation in his book "Planck oder Als das Licht seine Leichtigkeit verlor". He lets Planck go through all the options he probably had at the time. But the situation is more than muddled, no matter how one looks at it. Steffen Schroeder's book goes under the genre of the novel. But it is actually much more than that. Based on documented contemporary testimonies and events, it tells the story primarily of the sons of Max Planck and Albert Einstein in the last six months of the Second World War. Both Erwin Planck and Eduard Einstein stood in the shadow of their famous fathers. That is probably the only thing they had in common. For while Erwin Planck had a stellar career in politics during the Weimar Republic, Eduard Einstein spent many years in the Burghölzli psychiatric hospital.

Schroeder puts himself in the sons' shoes. He tries to understand the thoughts of the imprisoned Erwin Planck, which run through his head in his cramped cell in Berlin-Tegel, while he has to watch more and more of his comrades-in-arms being condemned and killed by the Nazis. At the same time, Schroeder swings to Burghölzli in Switzerland. There, Eduard Einstein works through his relationship with his famous father, who has emigrated to the USA and hardly maintains any contact with his son. It becomes clear: Eduard is pretty angry with his father. But Schroeder also puts himself in Albert Einstein's world of thought many thousands of kilometres across the Atlantic and thus provides insights into his character.

In Berlin, Max Planck does not comply with the request of the Reich Chamber of Culture. He writes a letter of refusal. His well-attended lectures on quantum physics gave him firm support during this time. But Planck feels that the light around which a large part of his research revolved and which once brought him ease has lost that very light in these days. In January 1945, Erwin Planck was hanged by the Nazis in Berlin-Plötzensee. Eduard Einstein survived the war and died in 1965, after spending a total of 14 years at Burghölzli.

In this book, documented history and contemporary testimonies merge with the author's ideas and interpretations. As empathetically as possible, Schroeder places himself in the thought worlds of the protagonists. Through the narration of the two family tragedies, one gains an entertaining and at times captivating insight into the biographies of two world-famous scientists and their sons. As it is to be read here, it could well have happened.



Planck or when light lost its lightness
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LMU

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

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

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

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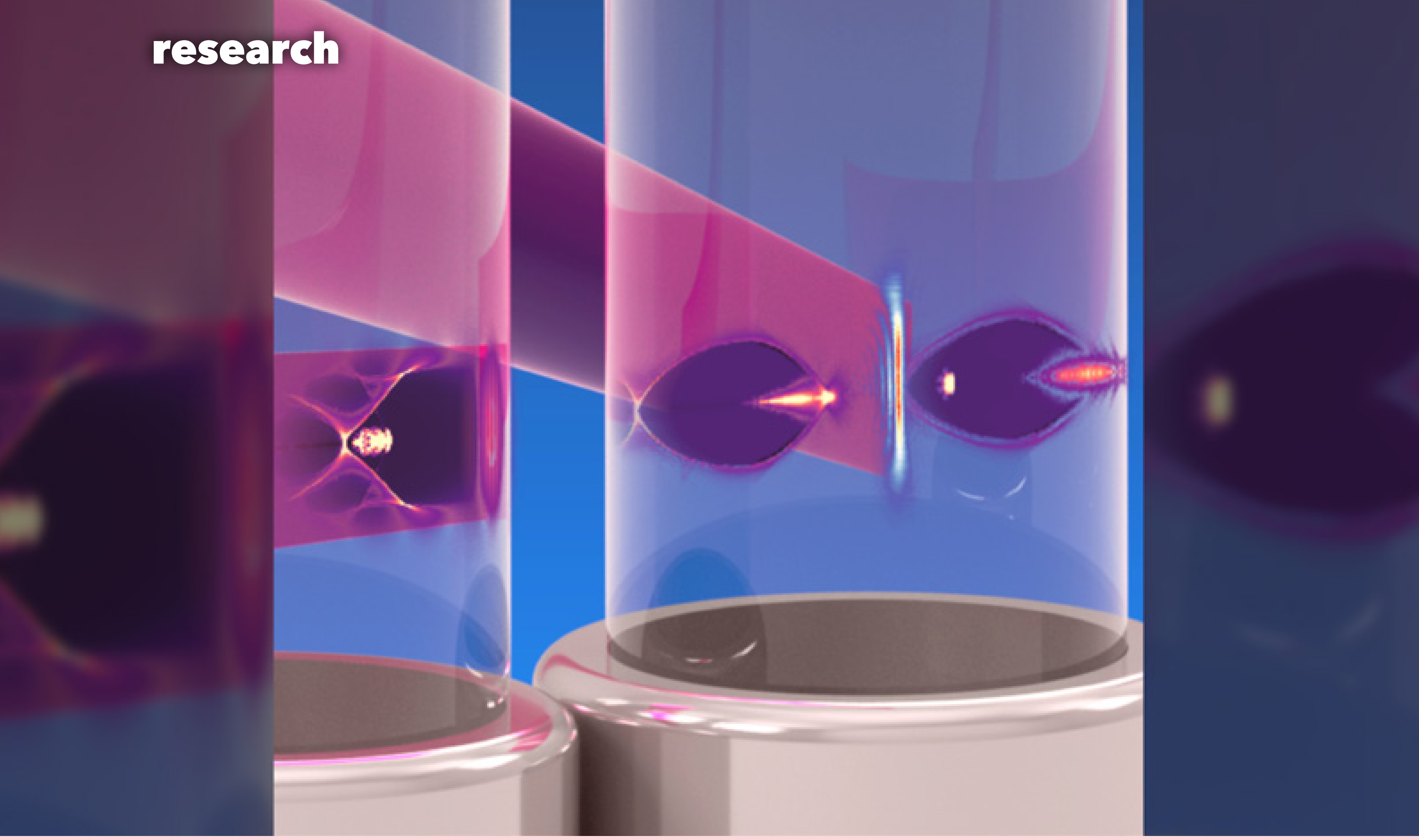

Artist's impression of wakefields in a two-stage plasma accelerator. Illustration: Moritz Foerster

more control over plasma accelerators

november 22, 2022 // high-field lasers and applications

If one particle accelerator alone is not enough to achieve the desired result, why not combine two accelerators? That's what physicists at the Centre for Advanced Laser Applications (CALA) at the Ludwig-Maximilians-Universität München (LMU Munich) thought in collaboration with colleagues at Helmholtz-Zentrum Dresden-Rossendorf, Laboratoire d'Optique Appliquée, Paris, DESY in Hamburg and the University of Strathclyde. They have combined two plasma-based acceleration methods for electrons, namely a laser-driven wakefield accelerator (LWFA) with a particle-beam-driven wakefield accelerator (PWFA). With this combination, they achieve better stability and higher particle density for electron beams than with just a single plasma accelerator. The tech marriage therefore opens up new perspectives for plasma-based particle acceleration.

original publication:

stable and high-quality electron beams from staged laser and plasma wakefield accelerators

Foerster et al.

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