

Pressemitteilung**Physikalisch-Technische Bundesanstalt (PTB)****Imke Frischmuth**

03.06.2024

<http://idw-online.de/de/news834566>Wettbewerbe / Auszeichnungen
Medizin, Physik / Astronomie, Werkstoffwissenschaften
überregional**Precision that excels: Helmholtz Prizes awarded to research groups from Konstanz, Hannover and Rostock**

Both of this year's Helmholtz Prizes prove what kind of groundbreaking success stories can be achieved with light. One is a newly developed microscopy technique, that can capture the extremely fast movements of atoms and electrons as if they were in a film. The other is an innovation in optical biopsy for skin cancer diagnostics. Both prizes are endowed with 20,000 euros each and will be awarded in Hamburg on 28 August 2024 as part of the XXIV IMEKO World Congress, during which the most recent developments "in the world of measurements" will be presented and discussed.

Both of this year's Helmholtz Prizes, which are being awarded for precision measurements in fundamental research and in applied metrology, prove what kind of groundbreaking success stories can be achieved with light. Using a newly developed microscopy technique, the physics research group of Prof. Dr. Peter Baum from the University of Konstanz managed to capture the extremely fast movements of atoms and electrons as if they were in a film. The researchers involved will receive the Helmholtz Prize in the field of fundamental research for this development. In the field of applied metrology, the prize will be awarded to an interdisciplinary team doing research into physics and medicine at Leibniz University Hannover (group headed by Prof. Dr. Bernhard Roth) and the University Medical Centre Rostock (Prof. Dr. Steffen Emmert's group). The team's innovations in optical biopsy for skin cancer diagnostics are being honored. Both prizes are endowed with 20,000 euros each and will be awarded in Hamburg on 28 August 2024 as part of the XXIV IMEKO World Congress, during which the most recent developments "in the world of measurements" will be presented and discussed.

Starting the film: Attosecond electron microscopy

Today's technological ambitions are reaching deep into the microworld, for instance, in terms of developing novel materials that need to have specific optical features. Other examples are the design of novel circuit methods for ultrafast electronics in information processing or the manipulation of electrons in quantum cryptography and quantum computing. All of these fields of application have one thing in common: They are part of a microworld in which the processes take place within unbelievably small time intervals. Typical time scales here are on the order of attoseconds (10⁻¹⁸ s).

The group of physicists led by Peter Baum has now found a novel way of accessing this "microworld of fast processes" by coupling laser light in an electron microscope at the same time, which causes a sequence of ultrashort electron pulses. In this way, they have managed to combine the atomic-scale spatial resolution of an electron beam with the attosecond timing of a laser wave. This basically allows us to directly watch the fundamental dynamics in complex structures of the microworld as a film in space and time.

This attosecond electron microscopy advances to completely new measurement ranges and is so flexible at the same time that it can be used to examine a wide variety of samples. Therefore, measurements are not limited to academic

materials, but almost all interesting natural or technical materials can be examined in this way. Companies from Japan and the USA have already shown an interest in using this development commercially. The first two patents have been already granted.

Without making a cut: optical biopsy in skin cancer diagnostics

According to the Federal Statistical Office of Germany, more than 100,000 patients in Germany alone are diagnosed with skin cancer every year. To specifically diagnose melanoma, a tissue sample needs to be surgically removed (biopsy) so that a histological examination can be performed. It usually takes a few days to get a result, and this involves significant mental stress for the patient. For this reason, there is an urgent need for non-invasive melanoma diagnostics.

In a joint effort that took several years, the interdisciplinary team led by Professor Roth (Leibniz University Hannover) and Professor Emmert (University Medical Centre Rostock) managed to develop a three-dimensional imaging method for imaging the skin structure, including the determination of the so-called invasion depth of skin lesions. For this purpose, four different measurement procedures were combined in one measuring instrument: optical coherence tomography (OCT), Raman spectroscopy (RS), photoacoustic tomography (PAT) and high-frequency ultrasound imaging (US).

The primarily laser-based system allows in-vivo measurements in clinical environments below the legally required exposure limits for human skin. It also increases the resolution in comparison with earlier approaches by a factor of 3 to 5 and has already been demonstrated on several dozens of lesions and patients in pre-clinical studies. As soon as the first data base is large enough, AI software is to be trained to be able to diagnose the lesions in a clinical environment. The next step will be conducting the required clinical studies over several years with the intention of establishing the system and then having it certified as a medical device.

The prize

The Helmholtz Prize sets a very special standard in the world of metrology. It is considered to be the “Nobel Prize in Metrology” and is therefore the flagship of the Helmholtz Fund e. V. This association awards the prize every two years for outstanding scientific and technological research in the field of precision measurement in physics, chemistry and medicine. The prize is awarded in two categories, fundamental research and applied metrology, with each prize endowed with 20,000 euros. The Helmholtz Fund e. V. is a unique non-profit association that has always been dedicated to promoting scientific progress in metrology. Honoring Hermann von Helmholtz, the co-founder and first President of the Imperial Physical Technical Institute (PTR), the association was named after him. The Helmholtz Fund e. V. thus pays tribute to this exceptional researcher.

jes/ptb

The prizewinners

2024 Helmholtz Prize: Precision Measurements in Fundamental Research:
David Nabben, Joel Kuttruff, Levin Stolz, Andrey Ryabov, Prof. Dr. Peter Baum
(Department of Physics, University of Konstanz)

2024 Helmholtz Prize: Precision Measurements in Applied Metrology:
Prof. Dr. Bernhard Roth, Anatoly Fedorov Kukk, Felix Scheling, Di Wu
(Leibniz University Hannover, Hannover Centre for Optical Technologies and Cluster of Excellence PhoenixD)
Prof. Dr. med. Steffen Emmert, Dr. med. Rüdiger Panzer

(University Medical Centre Rostock, Clinic and Policlinic for Dermatology and Venereology)

wissenschaftliche Ansprechpartner:

2024 Helmholtz Prize: Precision Measurements in Fundamental Research:

Prof. Dr. Peter Baum, Light and Matter Research Group, Department of Physics, University of Konstanz,
Universitätsstraße 10, 78464 Konstanz, Germany

Email: peter.baum@uni-konstanz.de

2024 Helmholtz Prize: Precision Measurements in Applied Metrology:

Prof. Dr. Bernhard Roth, Hannover Centre for Optical Technologies, Leibniz University Hannover, Nienburger Straße 17,
30167 Hannover, Germany, Email: bernhard.roth@hot.uni-hannover.de

Originalpublikation:

2024 Helmholtz Prize: Precision Measurements in Fundamental Research:

Nabben, D., Kuttruff, J., Stolz, L. et al. Attosecond electron microscopy of sub-cycle optical dynamics. Nature 619, 63–67
(2023). <https://doi.org/10.1038/s41586-023-06074-9>

2024 Helmholtz Prize: Precision Measurements in Applied Metrology:

Fedorov Kukk, F. Scheling, R. Panzer, S. Emmert, and B. Roth, “Combined ultrasound and photoacoustic C-mode
imaging system for skin cancer assessment”, Nature Scientific Reports (2023) 13:17947.

<https://doi.org/10.1038/s41598-023-44919-5>

The Helmholtz Fund and the Stifterverband für die Deutsche Wissenschaft e.V.
(Donors' Association for the Promotion of Science and Humanities in Germany) will award the

Helmholtz Prize 2024

**THINK
METROLOGY!**

XXIV World Congress
IMEKO 2024
26 – 29 August 2024
in Hamburg, Germany

Poster for the Helmholtz Prize