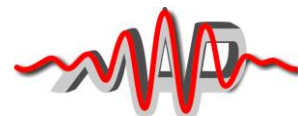




PRESS-RELEASE

Max Planck Institute of Quantum Optics and Munich-Centre for Advanced Photonics



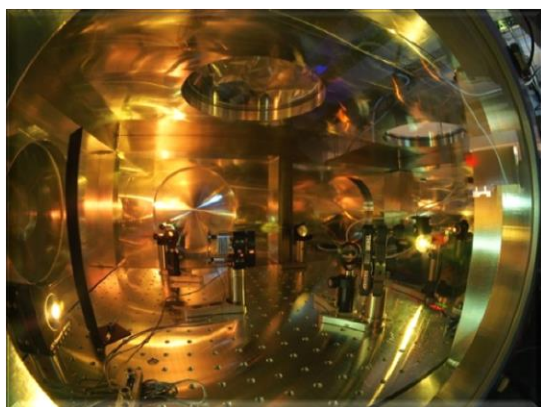
Garching, 20 February 2018

A quadrillionth of a second in slow motion

Observing and controlling ultrafast processes with attosecond resolution

Many chemical processes run so fast that they are only roughly understood. To clarify these processes, a team from the Technical University of Munich (TUM) has now developed a methodology with a resolution of quintillionths of a second. The new technology stands to help better understand processes like photosynthesis and develop faster computer chips.

An important intermediary step in many chemical processes is ionization. A typical example of this is photosynthesis. The reactions run extremely fast. They take only a few femtoseconds (quadrillionths of a second) or even merely a few hundred attoseconds (quintillionths of a second). Because of these extremely short time scales, the initial and final products are known, but not the reaction paths or the intermediate products.



To observe such ultrafast processes, science needs a measurement technology that is faster than the observed process itself. So-called “pump and probe” spectroscopy makes this possible.

Here, the sample is excited using an initial laser pulse, which sets the reaction into motion. A second, time-delayed pulse queries the state of the sample at that moment. Multiple repetitions of the reaction with different time delays result in individual stop-motion images, which can then be compiled into a “film clip”.

*(Measuring chamber at TUM's Department of Physics,
Photo: Birgitta Bernhardt)*

Two eyes see more than one

Now, a team of scientists headed by Birgitta Bernhardt, a former staff member at the Chair of Laser and X-ray Physics at TU Munich, who is now junior professor at the Institute of Applied Physics at the University of Jena, have for the first time succeeded in combining two pump and probe spectroscopy techniques using the inert gas krypton. This allowed them to shed light on the ultrafast ionization processes in a precision that has simply not been possible hitherto.

“Prior to our experiment, you could observe either which part of the exciting light was absorbed by the sample over time or measure what kind of and how many ions were created in the process,” explains Bernhardt. “We have now combined the two techniques, which allows us to observe the precise steps by which the ionization takes place, how long these intermediate products exist and what precisely the exciting laser pulse causes in the sample.”

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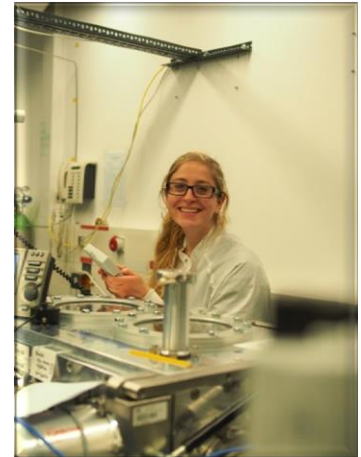
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Ultrafast processes under control

The combination of the two measuring techniques allows the scientists not only to record the ultrafast ionization processes. Thanks to the variation in the intensity of the second, probing laser pulse, they can now, for the first time, also control and in this way also influence the ionization dynamics.

“This kind of control is a very powerful instrument,” explains Bernhardt. “If we can precisely understand and even influence fast ionization processes, we stand to learn a lot about light-driven processes like photosynthesis – especially about the initial moments in which this complex machinery is set into motion and which is hardly understood to date.”

(Prof. Birgitta Bernhardt at the measuring chamber, Photo: Michael Mittermair)



Ultrafast computers

The technology developed by Bernhardt and her colleagues is also interesting for the development of new, faster computer chips in which the ionization of silicon plays a significant role. If the ionization states of silicon can not only be sampled on such a short time scale, but can also be set – as the first experiments with krypton suggest – scientists might one day be able to use this to develop novel and even faster computer technologies.

Further information:

The work is the result of a collaboration between the workgroups led by Prof. Reinhard Kienberger, Chair of Laser and X-ray Physics at TU Munich and Max Planck Fellow at the Max Planck Institute of Quantum Optics in Garching and Stephan Fritzsche, professor at the Institute of Theoretical Physics of the Friedrich Schiller University of Jena.

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