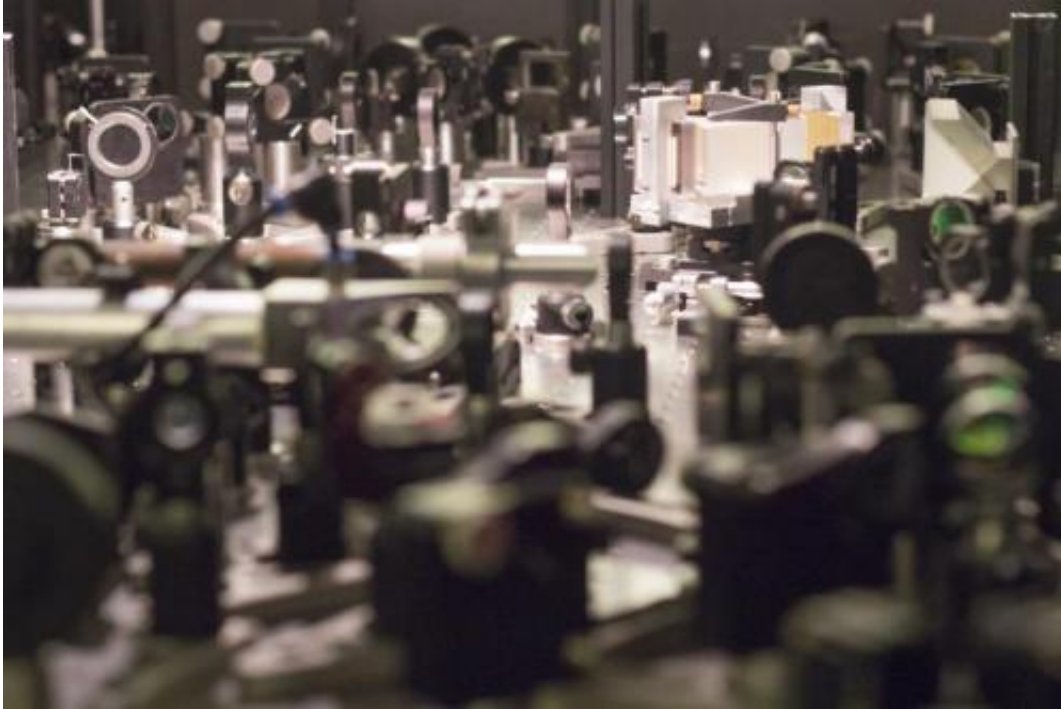


# Creating bright X-ray pulses in the laser lab

November 11 2014

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An optical table at the Photonics Institute (TU Wien). Credit: TU Wien

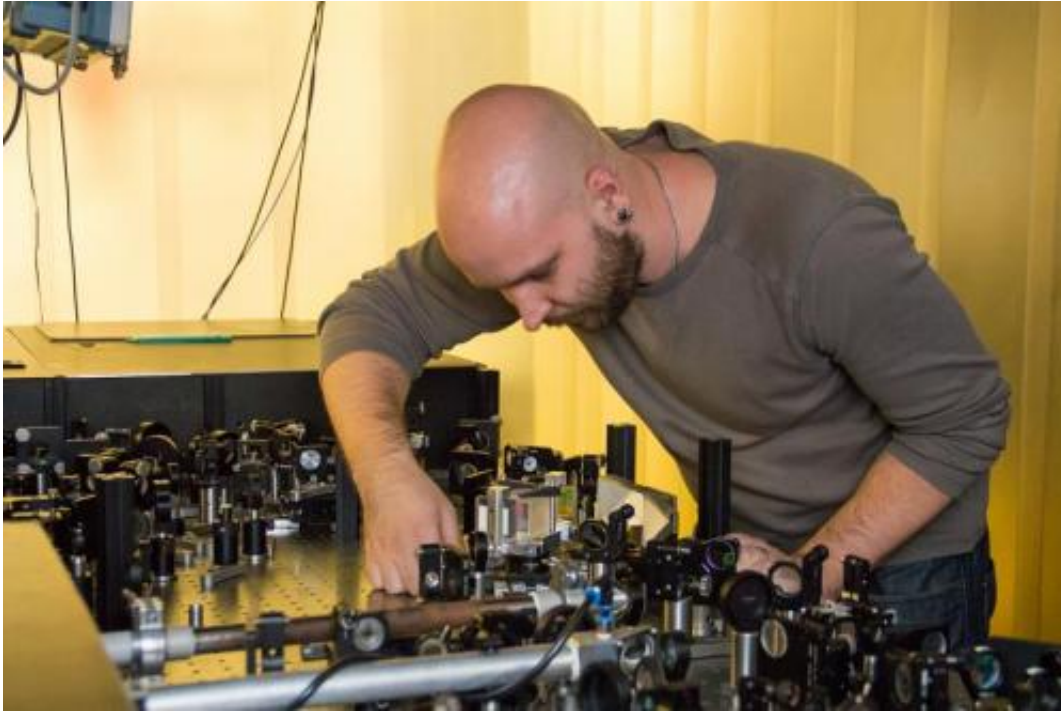
To create X-rays—short wave radiation—scientists at TU Vienna start out with very long wavelengths—infrared laser. Long wavelength laser pulses rip atoms out of metal and accelerate them, which leads to emission of X-rays.

X-rays are widely used in medicine and in materials science. To take a picture of a broken bone, it is enough to create a continuous flux of X-ray photons, but in order to study time-dependent phenomena on very

short timescales, short X-ray pulses are required. One possibility to create short hard X-ray pulses is hitting a metal target with laser pulses. The laser rips electrons out of the atoms and makes them emit X-ray radiation. Electrical engineers at the Vienna University of Technology (TU Wien) together with researchers from Berlin have drastically increased the flux of X-ray photons using a newly developed mid-infrared laser system. This new table-top X-ray source will allow more accurate measurements in many fields of research.

## **Long Waves and Short Waves**

Hard x-ray radiation is light with a [wavelength](#) in the range of picometers - much shorter than the wavelength of visible light. But in order to create this extremely short wave radiation, Professor Andrius Baltuska's team (Photonics Institute, Electrical Engineering, TU Wien) starts out with a quite different kind of light. They created a high-intensity [infrared laser](#) system with a wavelength of 4 micrometers - which is a wavelength much longer than visible light.



Skirmantas Alisauskas working on the experiment. Credit: TU Wien

The mid-infrared light emitted by the laser hits a copper plate. The intensity of the laser light is so high that electrons are ripped out of the atoms. The laser field turns them around, accelerates them and eventually makes them hit the copper again at very high energies. During this impact of the electrons returning to the copper plate, X-ray radiation is emitted.

"The flux of the x-ray radiation depends on the wavelength of the laser", says Skirmantas Alisauskas (TU Wien). "If the [laser wavelength](#) is long, then every electron spends a lot of time in the laser field before it returns to the copper atoms. It has more time to gain energy and hits the copper plate even harder."

## **Building a New Kind of Laser**

This is why the scientists have focussed their attention on building long-wavelength laser systems. "Previously, this experiment was done with a common 0.8 micrometer laser. The wavelength of our [laser pulses](#) is five times as long, which translates into a 25 times higher x-ray flux", says Skirmantas Alisauskas. Each laser pulse leads to one billion [x-ray photons](#), emitted into all directions.



Skirmantas Alisauskas, Vienna University of Technology. Credit: TU Wien

Creating this laser light was a big technological challenge. "Building lasers with such long wavelengths is hard, but the main problem was

making the laser light intense enough", says Alisauskas. "At this wavelength, this is the most intense [laser light](#) in the world. But we want to go even further in the near future."

## More Pulses per Second

The team is planning to go to even longer wavelengths, and they are trying to increase the rate at which the laser can produce light pulses. "At the moment, we have a repetition rate of 20 [laser](#) pulses per second. That is perfectly fine for a proof of principle, but for technological applications we need to increase that - and we already have a few good ideas of how to do this", says Prof. Andrius Baltuska.

X-rays are used whenever the atomic structure of materials has to be investigated. As the new x-ray source does not produce a continuous beam but short pulses, it can be used for time-resolved measurements.

**More information:** High-brightness table-top hard X-ray source driven by sub-100-femtosecond mid-infrared pulses, *Nature Photonics* (2014) [DOI: 10.1038/nphoton.2014.256](https://doi.org/10.1038/nphoton.2014.256)

Provided by Vienna University of Technology

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