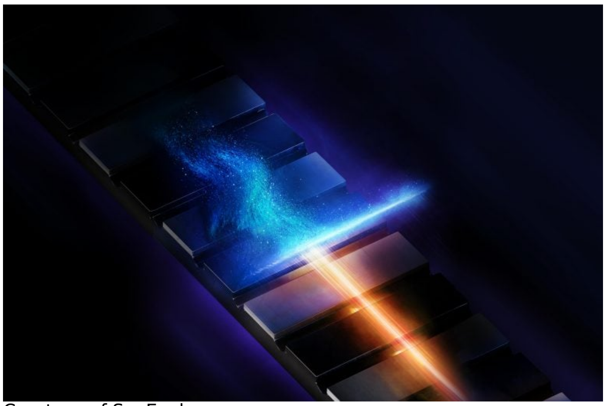
The Invisible Is Illuminated By High-Power X-rays.

Posted by Okachinepa 11/28/2024



Courtesy of SynEvol
Credit: European XFEL

By developing high-power attosecond hard X-ray pulses with megahertz repetition rates, a group of scientists from European XFEL and DESY has made a significant contribution to X-ray science. This accomplishment creates new avenues for non-destructive atomic-scale measurements and the investigation of ultrafast electron dynamics. On November 25, the researchers' results were reported in Nature Photonics.

The scientists produced single-spike hard X-ray pulses that lasted barely a few hundred attoseconds and had energies greater than 100 microjoules. To put things in perspective, an attosecond is one quintillionth of a second, which is so short that it allows scientists to see the fastest motions of electrons in matter.

The primary author of the work published in Nature Photonics, Jiawei Yan, a physicist at European XFEL, says, "These high-power attosecond X-ray pulses could open new avenues for studying matter at the atomic scale." These special X-rays allow us to measure structural and electrical characteristics with practically no harm. This opens the door to more complex research, such as attosecond crystallography, which enables us to see electronic dynamics in real space.

The pulse energy and practical use were restricted by the need to drastically reduce the electron bunch charge to tens of picocoulombs in order to generate such ultra-short hard X-ray pulses using traditional methods. Using the combined impacts of electron beams and specific beam transport systems at the European XFEL, the researchers created a self-chirping technique. With this method, attosecond X-ray pulses can be produced at megahertz repetition rates and terawatt-scale peak power without lowering the electron bunch charge.

Gianluca Geloni, group leader of the FEL physics group at the European XFEL, says, "We can now collect data much faster and observe processes that were previously hidden from view by combining ultra-short pulses with megahertz repetition rates." "This breakthrough has the potential to revolutionize research in a variety of scientific domains, particularly in the areas of atomic-scale imaging of materials and protein molecules and the study of nonlinear X-ray phenomena."