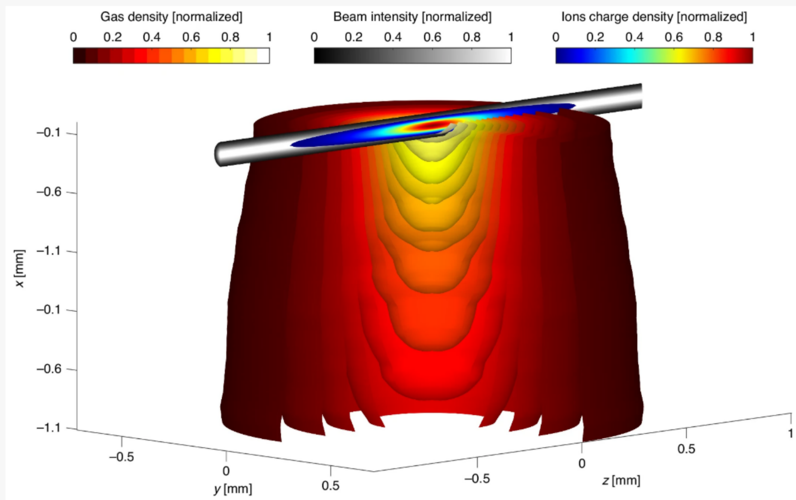
Physicists from Ben-Gurion University Achieve Breakthrough in Measuring Ultrafast Laser Pulses

GA, UNITED STATES, April 28, 2025 /EINPresswire.com/ -- Researchers at Ben-Gurion University have achieved a major breakthrough in measuring ultrafast laser pulses, overcoming a long-standing challenge in strong-field physics. Led by Dr. Eugene Frumker, the team developed a precise method to measure laser intensity and duration at the interaction point using ion analysis. This advancement improves accuracy in laser-driven experiments, paving the way for new discoveries in attosecond science and strong field physics.



The argon gas jet was measured and tomographically reconstructed with a back pressure of 7.5 bar and a laser intensity of 0.5 mJ. The maximum ions charge density is , and the maximum gas density is . Gas jet is visualized as cut-outs within isosurfaces

A research team from Ben-Gurion University of the Negev has successfully measured and characterized extremely powerful laser pulses lasting just a few femtoseconds—an achievement that overcomes a decades-old challenge in strong-field physics and attosecond science.

The research group, led by Dr. Eugene Frumker, has developed a groundbreaking method to accurately determine the intensity and duration of these ultrafast pulses—a crucial advancement for improving precision in laser-driven experiments.

Their findings were just published in one of the top journals in the field, Light: Science & Applications (LSA).

Amplified ultrafast laser pulses are among the most intense bursts of energy ever created—briefly surpassing the combined power output of all the world's power stations, though only for a few millionths of a billionth of a second. In attosecond science experiments, these pulses are tightly focused to a spot smaller than the width of a human hair, where they interact with matter at extreme intensities.

However, a long-standing challenge has been the difficulty of precisely measuring these laser pulses at the point of interaction. Existing methods can be inaccurate by as much as 50%, leading to uncertainty in experimental results. Without knowing the exact intensity and duration of these pulses, scientists cannot achieve the level of precision required for cutting-edge discoveries.

Dr. Frumker and Noam Shlomo, a Ph.D. student in his research group, have developed a breakthrough method to directly measure the laser's intensity and duration at the point of interaction with atoms, providing significantly greater accuracy than previous techniques.

“At first glance, the problem may seem straightforward: simply measure fundamental laser pulse characteristics such as energy, width, and duration, then calculate the peak intensity. However, it has long been known that this approach often results in unacceptably large errors,” says Dr. Frumker.

“Moreover, high-power ultrafast laser systems often experience fluctuations in pulse intensity and variations in their spatial and temporal profiles. Given the highly nonlinear nature of strong-field interactions, these factors further complicate the problem. That’s why a reliable in situ method to accurately measure and control these parameters in the interaction region is critical for all areas of strong-field laser physics.”

Their method works by analyzing ions—electrically charged atoms—created when the laser interacts with a gas. By carefully measuring these ions, the team can precisely determine the laser’s intensity and duration at the exact point of interaction. They have successfully tested this technique with different gases, such as helium and argon, demonstrating its reliability and consistency. Additionally, their theoretical model closely aligns with their experimental data, further validating their approach.

This breakthrough represents a major step forward for strong field and attosecond science, enabling more precise experiments that could lead to a deeper understanding of atomic and molecular behavior on ultrafast timescales. While the primary impact is on fundamental scientific research, this advancement could also contribute to future technologies in areas such as ultrafast electronics, advanced materials, and even next-generation medical imaging and diagnostics.

References

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Lucy Wang
BioDesign Research
email us here
