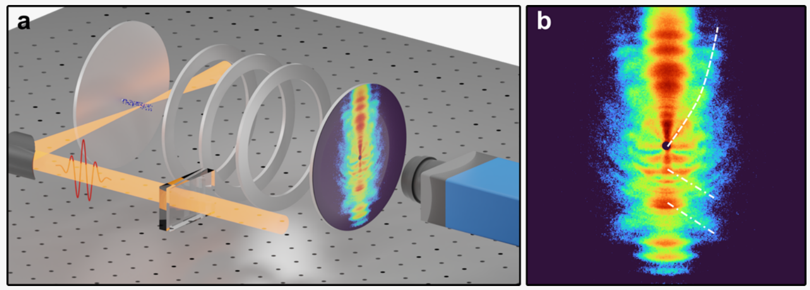
Strong-field photoelectron holography in the subcycle limit

USA, May 20, 2024 /EINPresswire.com/ -- Utilizing a near-single-cycle strong laser field, inter-cycle interference between photoelectron trajectories is mitigated in photoelectron holography, clearly unveiling two unique electron-holography patterns: fishbone-like and spider-leg-like. This study also reveals that the Gouy phase effect distorts the electron holography pattern and thus should be properly taken into account for the accurate determination of inter-nuclear separation. This breakthrough advances strong-field photoelectron holography one step further toward practical ultrafast molecular structure imaging.



Observation of spider-leg-like and fishbone-like photoelectron holographic patterns.

Scientists Unveil Fundamental Electron-holograms for Ultrafast imaging of Atoms and Molecules

A team of scientists led by Professor Dong Eon Kim at the Pohang University of Science and Technology and Professor X. Lai at the Innovation Academy for Precision Measurement Science and Technology achieved a breakthrough in ultrafast imaging by separately and clearly observing two distinct holographic patterns, spider-leg- and fishbone-like, for the first time. They utilized near-single-cycle laser pulses not only to unveil and identify spider-leg-like and fishbone-like patterns, but also the Gouy phase effect on the electron hologram. This study opens an avenue for correctly extracting the internuclear separation of a target molecule from a holographic pattern.

Traditional imaging methods, such as X-ray diffraction, have limitations in capturing the rapid movement of electrons within molecules. This new approach, based on strong-field photoelectron holography (SFPH), promises to revolutionize our understanding of these fundamental building blocks with an unprecedented resolution. By using carrier-envelope-phase-controlled, near-single-cycle laser pulses, the team was able to clearly visualize and identify distinct holographic patterns, revealing details of electron dynamics within a target molecule because inter-cycle interference patterns that had previously hampered SFPH measurements were suppressed. "For the first time, these patterns have been directly observed," explained Professor Kim.

"Our approach allows us to control electron behavior on an attosecond timescale [an attosecond is a billionth of a billionth of a second]."

The researchers demonstrated the power of their method by extracting structural information about the target molecule. The results find applications in fields ranging from chemistry and biology to materials science.

Simplified Approach, Exciting Possibilities

Importantly, this new approach is simpler than previous methods that often require multiple measurements. This advancement is versatile, with the potential to be combined with other techniques to provide even more precise control and insights.

"Our work opens up exciting avenues for studying molecular dynamics and controlling chemical reactions," remarked Professor Kim.

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