Attosecond control of an atomic electron cloud

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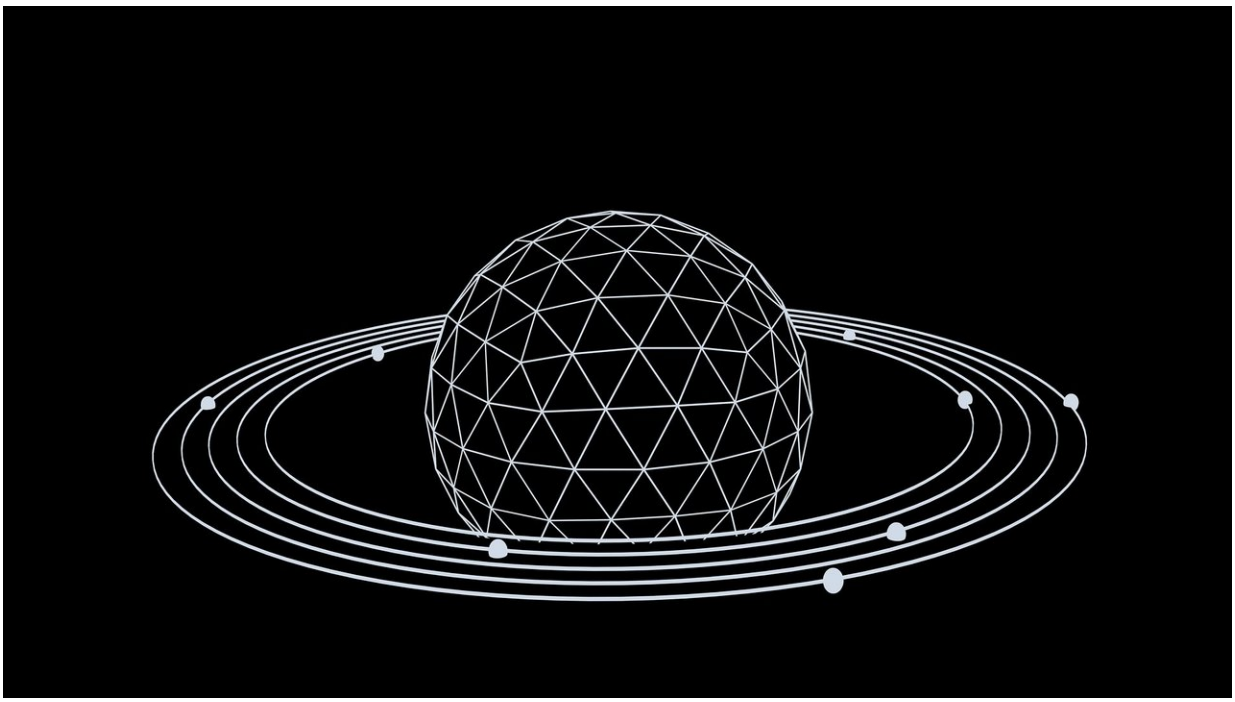

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Researchers at SAGA Light Source, the University of Toyama, Hiroshima University and the Institute for Molecular Science have demonstrated a method to control the shape and orientation of an electron cloud in an atom by tuning the attosecond spacing in a double pulse of synchrotron radiation.

Working as a collaborative research team, Tatsuo Kaneyasu (SAGA Light Source/Institute for Molecular Science), Yasumasa Hikosaka (University of Toyama), Masahiro Katoh (Hiroshima University/Institute for Molecular Science) and co-workers have invented a way to manipulate the shape of an electron cloud in an atom using the coherent control technique with synchrotron radiation. The work, which has been published in *Physical Review Letters*, paves the way towards the ultrafast control of electronic systems using synchrotron radiation.

Controlling and probing electronic motion in atoms and molecules on their natural time scale of attoseconds is one of the frontiers in atomic physics and attosecond physics. Thanks to advances in laser technology, a number of attosecond experiments have been performed with ultrashort laser pulses. In contrast, this research team has presented a new route to the attosecond coherent control of electronic systems using synchrotron radiation. The potential use of undulator radiation as longitudinally coherent wave packets was demonstrated by achieving population control in the photoexcitation of helium atoms [Y. Hikosaka et al., *Nature Commun.* 10, 4988 (2019)]. The next challenge was the application of the polarization properties of the synchrotron radiation to coherent control.

The team's latest paper, recently published in *Physical Review Letters*, reports a successful observation of the control of the electron cloud in a helium atom. Pairs of left- and right-circularly polarized radiation wave packets were generated using two helical undulators. The duration of each wave packet pair was a few femtoseconds, and extreme ultraviolet radiation was used to irradiate helium atoms. With this technique they succeeded in controlling the shape and orientation of the electron cloud, formed as a coherent superposition state, by tuning the time delay between the two wave packets on the attosecond level.

In contrast to standard laser technology, there is no technical restriction

on the extension of this method to shorter and shorter wavelengths. This new capability of synchrotron radiation not only helps scientists to study ultrafast phenomena in atomic and molecular processes, but may also open up new applications in the development of functional materials and electronic devices in the future.

More information: T. Kaneyasu et al, Controlling the Orbital Alignment in Atoms Using Cross-Circularly Polarized Extreme Ultraviolet Wave Packets, *Physical Review Letters* (2019). DOI: 10.1103/PhysRevLett.123.233401

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