The hidden ability of synchrotron radiation to perform coherent control

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Coherent control is a method to manipulate the populations and pathways in matter by light, and is currently one of the most attractive research areas in optical physics and photochemistry. Lasers have been considered as unique light sources enabling one to perform coherent control, and, thanks to the development of laser technology, the on-going research is moving rapidly into the regime of extreme ultraviolet wavelengths.

Synchrotron radiation from relativistic electrons is widely-used light with a continuous spectrum extending as far as the hard X-ray range. Synchrotron radiation is usually considered as being of poor temporal coherence, therefore it was not previously conceived to have a hidden capacity for coherent control. Yasumasa Hikosaka (University of Toyama), Tatsuo Kaneyasu (SAGA Light source/Institute for Molecular Science [IMS]), Masahiro Katoh (Hiroshima University/IMS) and co-workers have demonstrated this capability by achieving wave-packet interferometry on electron wave packets generated in Helium atoms.

The researchers employed two identical undulators installed in a straight section of the UVSOR-III storage ring at Okazaki, Japan. The twin undulators generated a pair of linearly-polarized electromagnetic wave packets, where each of the light wave packets had a duration of ~1.8 fs, and the delay time between them could be adjusted with attosecond precision.

The researchers' idea was that the longitudinal coherence between two of

the light wave packets can be utilized in implementing coherent control. The researchers illuminated helium atoms with synchrotron radiation from the twin undulators, and generated in the helium an electron wave packet pair transcribed from the light wave packet pair. They demonstrated that the populations of the individual excited states can be controlled by adjusting the interference between the electron wave packets.

This prototypical experiment verified a novel coherent-control framework with synchrotron radiation. There is no technical restriction on the application of this coherent-control concept at shorter wavelengths to which lasers could soon reach. This unexploited capability of synchrotron radiation will advance the frontier of coherent-control technology.

More information: Y. Hikosaka et al, Coherent control in the extreme ultraviolet and attosecond regime by synchrotron radiation, *Nature Communications* (2019). DOI: 10.1038/s41467-019-12978-w

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