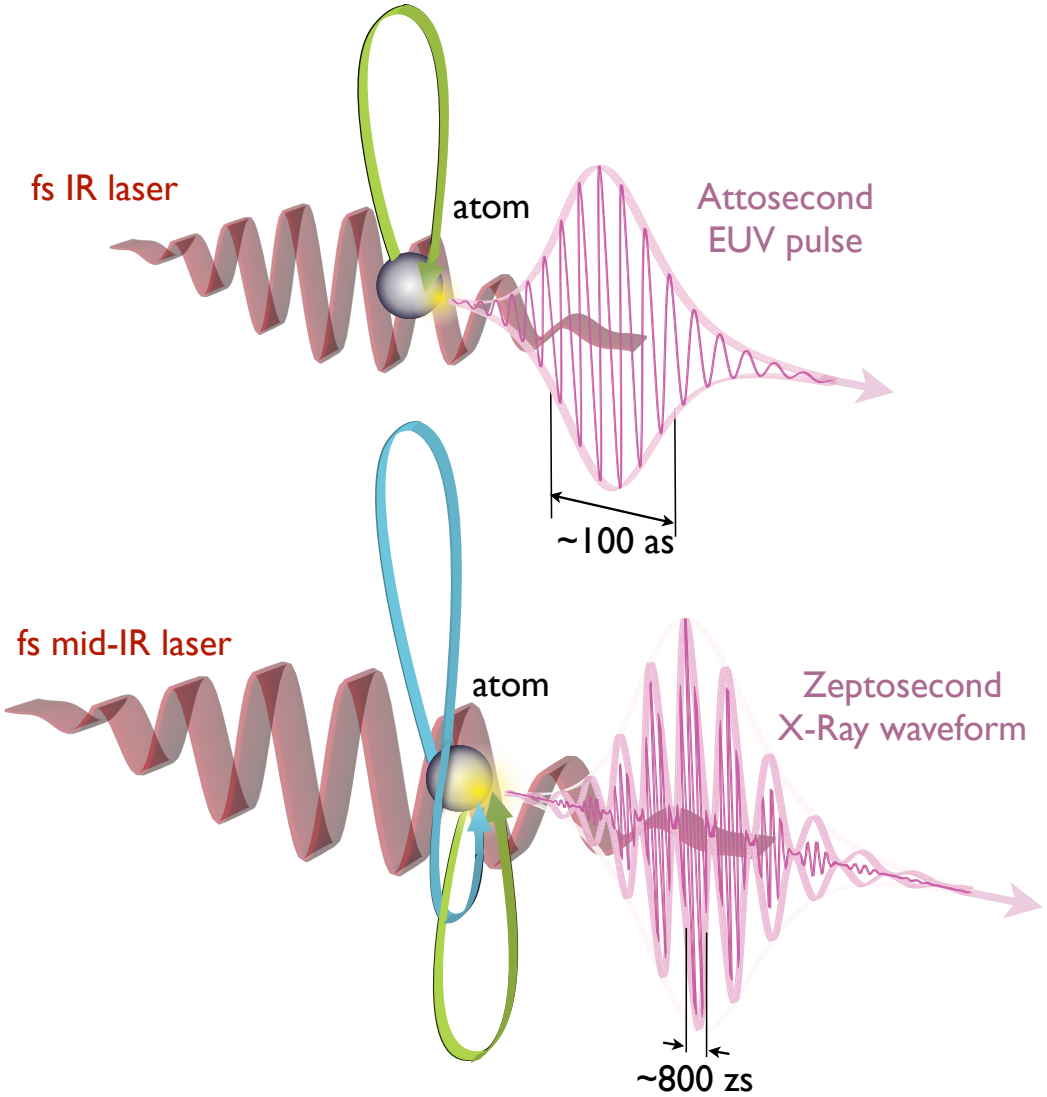
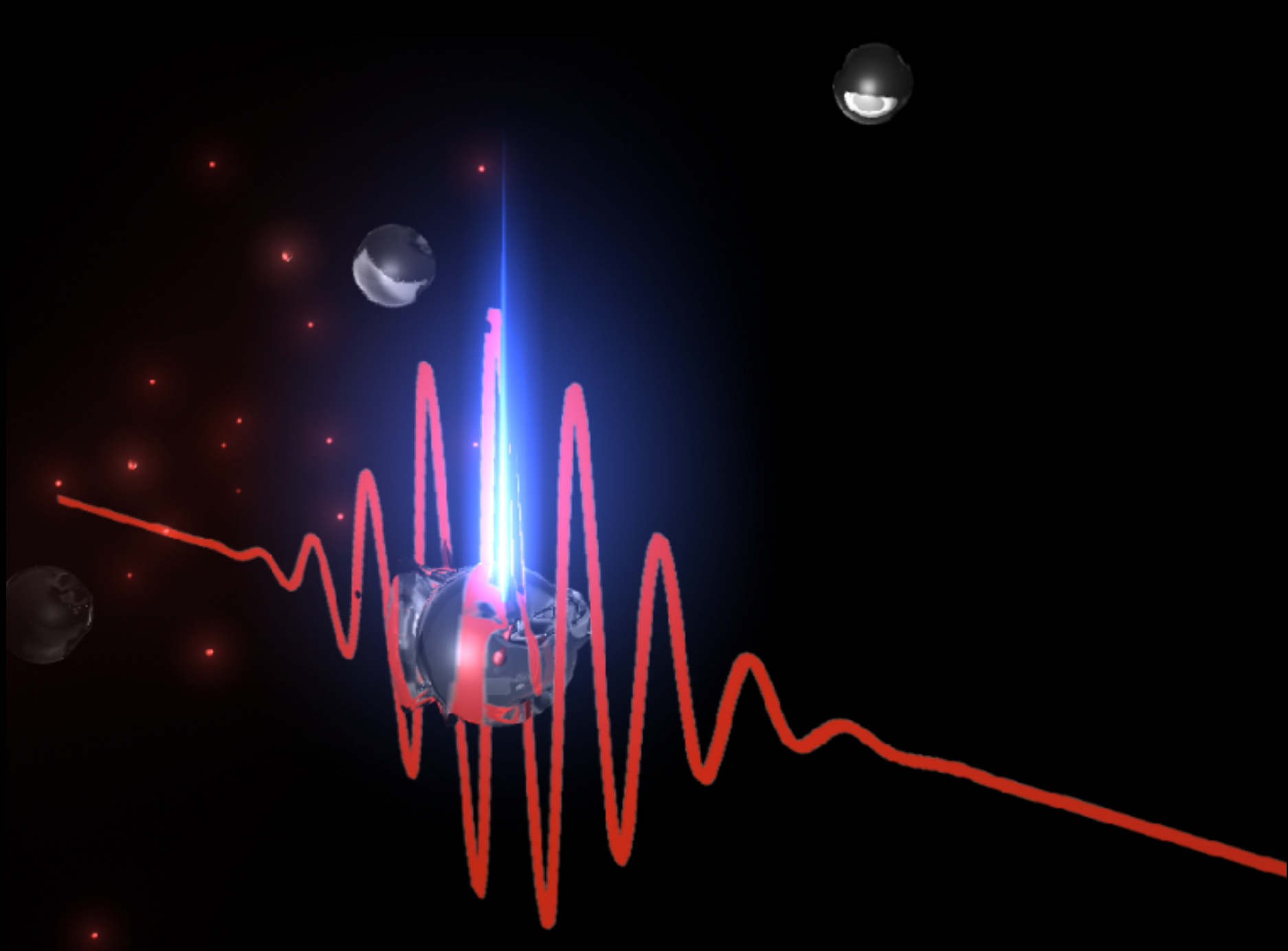
Fig. 1.



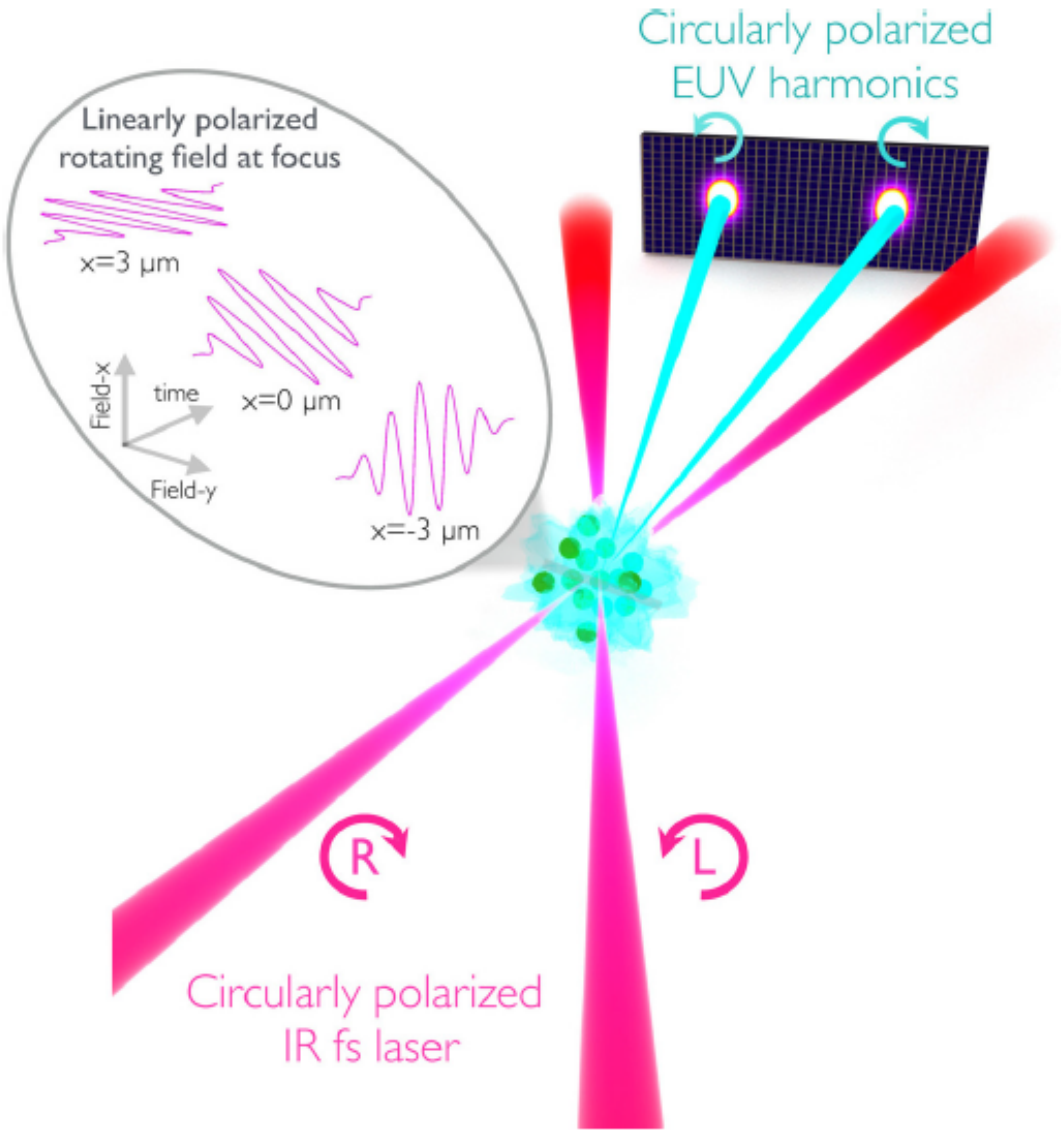
Zeptosecond X-ray waveform generation. (top) In standard high-harmonic generation, a femtosecond laser removes an electron from an atom, then drives it back to the parent ion. The electron recombines with the ion, releasing its energy in the form of an attosecond pulse with a wavelength in the extreme ultraviolet region of the spectrum. (bottom) In zeptosecond pulse generation, two electronic wave packets generate x-ray bursts that interfere and create a waveform with amplitude beats hundreds of zeptoseconds long — a thousand times shorter than is possible today. [Phys. Rev. Lett., 111, 033002 (2013)].

Fig. 2.



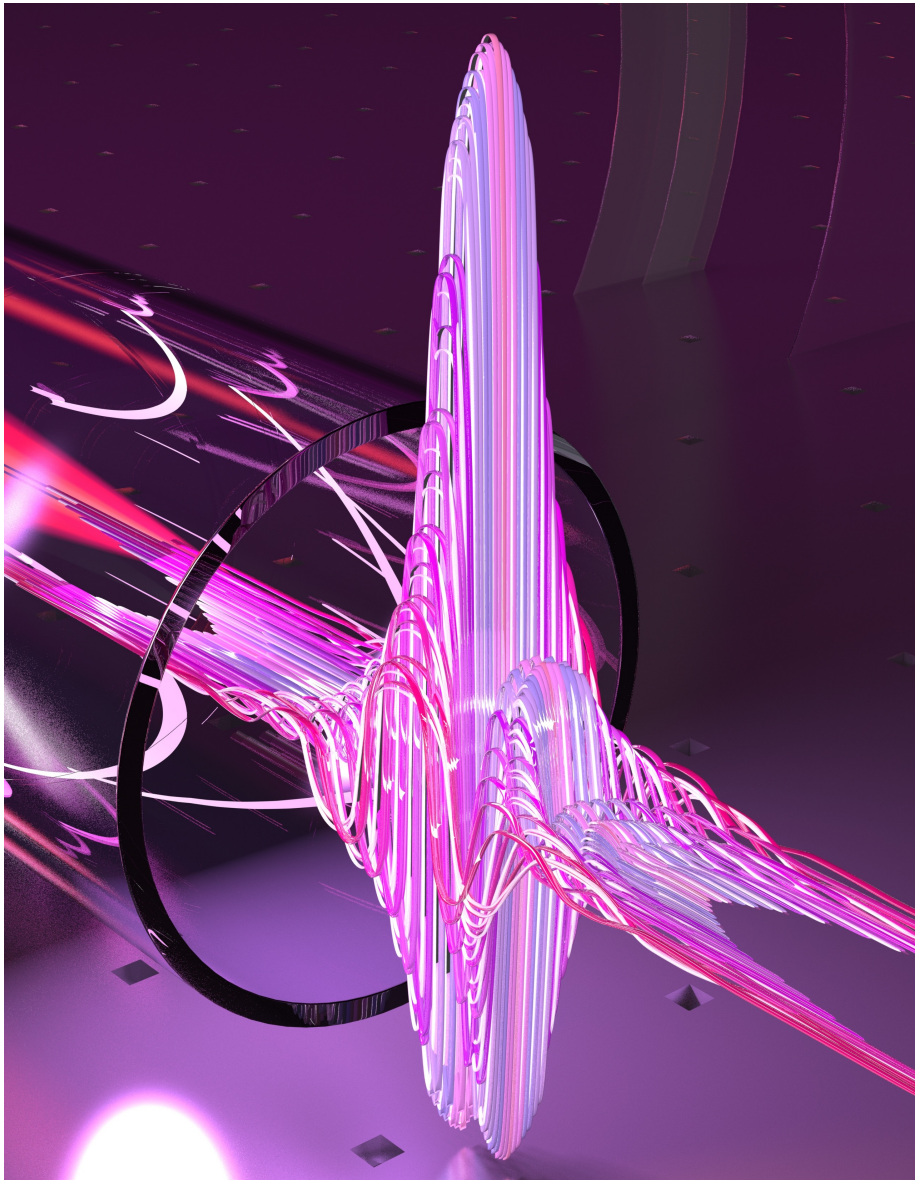
Isolated soft x-ray attosecond pulses. When a mid-infrared laser beam (red) is focused into a gas jet, an isolated attosecond pulse emerges as a result of favorable phase-matching conditions [PNAS, 111, E2361, (2014)] (Figure courtesy of Ming-Chan Cheng).

Fig. 3.



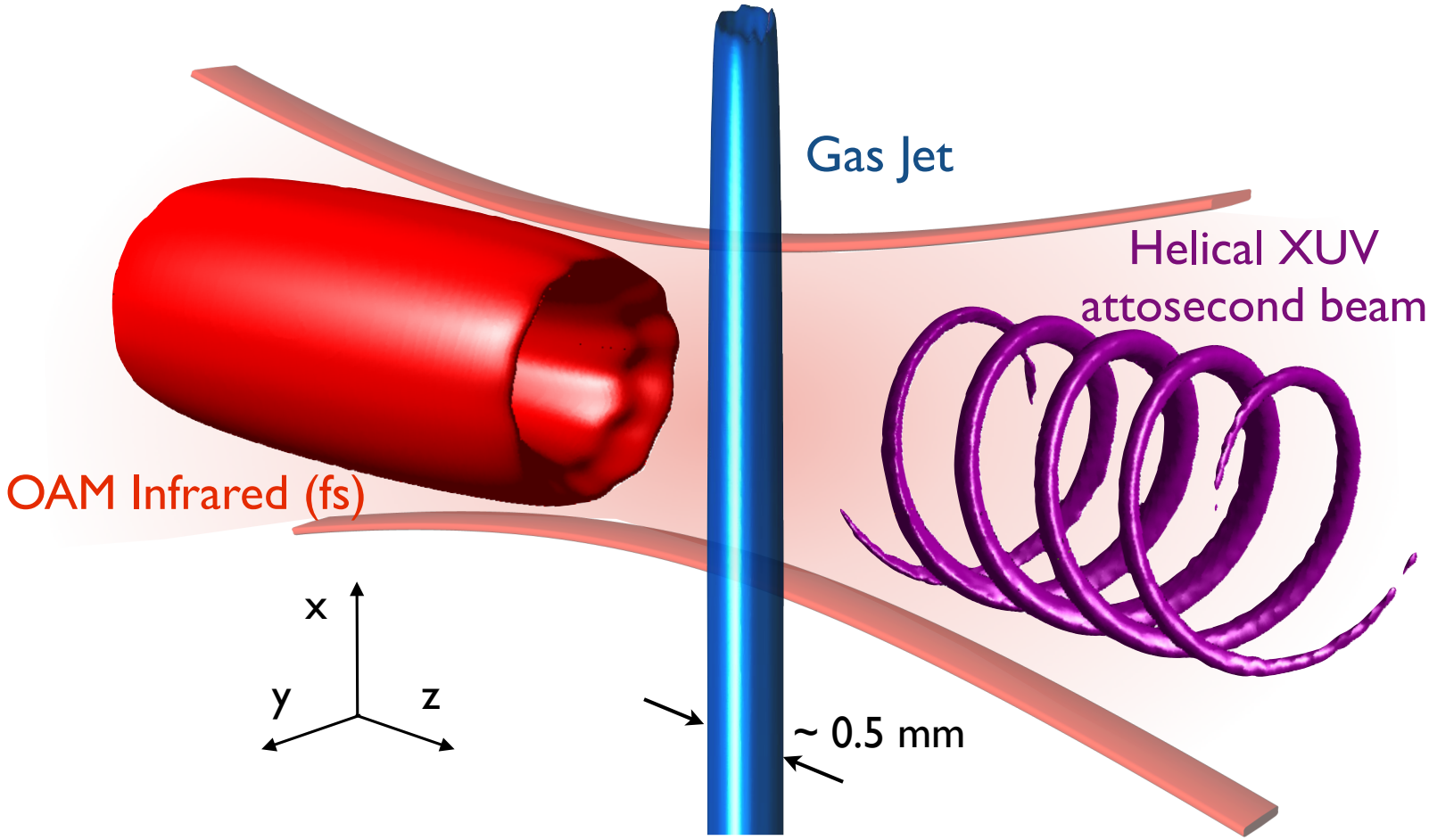
Generation of circularly polarized attosecond pulses. When two non-collinear, counter-rotating infrared beams are focused into a gas jet, two circularly polarized harmonic beams are emitted in the far field. If several harmonics are combined, circularly polarized attosecond pulses are obtained. [Nature Photonics, 9, 743- 750, (2015); Physical Review A, 93, 043855 (2016)].

Fig. 4.



The ultraviolet surprise: generation of soft x-ray harmonics from UV lasers. Art figure representing the obtention of soft x-ray attosecond pulses when driving high-order harmonic generation with UV lasers inside an argon-gas filled waveguide. [Science 350, 1225-1231 (2015)] (Figure courtesy of T. Popmintchev).

Fig. 5.



Helical extreme-ultraviolet attosecond beam driven by HHG. An infrared fs vortex beam carrying orbital angular momentum with $\ell = 1$, is focused into an argon jet. The highly nonlinear laser-matter interaction results in the generation of an helical attosecond beam of higher energy (extreme ultraviolet or even x-ray). [Phys. Rev. Lett., 111, 083602 (2013)]