Attosecond water-window soft X-ray source for XANES

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We present a table-top high harmonic light source producing isolated attosecond soft x-ray pulses with a bandwidth covering the entire water window (200 to 550 eV), including the fundamental absorption edges of carbon, nitrogen and oxygen. The source provides the highest reported attosecond soft x-ray flux to date and was used to demonstrate X-ray Absorption Near Edge Structure (XANES) spectroscopy of an organic film and relevant solar cell material.

Our attosecond source is driven by a 1850 nm pulse which is generated from a cryogenically cooled two-stage Ti:Sapphire laser and non-collinear optical parametric amplification (OPA) [1]. A carrier-envelope phase (CEP) stable sub-2 cycle pulse with 0.45 mJ energy at 1 kHz repetition rate is focused into a 10 bar helium target in which it generates, via high harmonic generation (HHG) an isolated chirped attosecond pulse, with 350 as pulse duration [2]. Important features for experimental applications are i) sufficient flux, ii) coverage below and above the absorption edge of relevance, and iii) spectral reproducibility. Our source satisfies these combined conditions for the first time: The CEP stability of better than 100 mrad over 72 h ensures spectral stability and we determine high flux water window radiation with $(1.8 \pm 0.1)\cdot 10^7$ photons/s within 10% bandwidth in the area of interest (294 eV and 410 eV) [3]. In addition, the attosecond radiation covers L-shell edges from argon, potassium, calcium, scandium, titanium to vanadium and M-shell edges from almost 20 more elements such as selenium, molybdenum, cadmium and indium.

We identify individual transitions from 1s core states within the N and C atoms inside an organic film which is used for organic electronics and organic solar cell research. This demonstration shows that attosecond technology will be useful to elucidate charge excitation and, more importantly, charge motion across the different sites of a material with attosecond temporal resolution.

References

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[3] S. M. Teichmann et al., Nature Communications 7, 11493 (2016)