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Multi-color operation via coherent harmonic generation in a plasma driven attosecond X-ray source

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The ongoing Plasma-driven Attosecond X-ray source experiment (PAX) at FACET-II aims to produce coherent soft x-ray pulses of attosecond duration using a Plasma Wakefield Accelerator [1]. These kinds of X-ray pulses can be used to study chemical processes where attosecond-scale electron motion is important. As a future upgrade to this concept, we investigate scaling to shorter soft X-ray wavelength by cascading undulators tuned to higher harmonics of the fundamental in a coherent harmonic generation (CHG) configuration. This configuration leverages the increase in the bunching factor of the higher harmonics to produce radiation at the fifth and tenth harmonics, corresponding to radiation wavelengths of 2 nm and 1 nm. In this contribution, we consider two CHG schemes. The first consists of using three 20 period-long undulator stages tuned to the fundamental, the fifth harmonic, and the tenth harmonic respectively, while the second consists of 20 periods at the fundamental, then 40 at the tenth harmonic. We demonstrate in both of these schemes using undulators with retuned fundamental frequencies can produce TW-scale pulses of fifth and tenth harmonic radiation with tens of attosecond-scale pulse lengths, an order of magnitude shorter than current state-of-the-art attosecond XFELs.

[1] C. Emma, X.Xu et al APL Photonics 6, 076107 (2021)

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