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## Non-linear Harmonics of a Seeded FEL at the Water Window and Beyond

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The advent of free electron lasers (FELs) in the soft and hard X-ray spectral region has opened the possibility to probe electronic, magnetic and structural dynamics, in both diluted and condensed matter samples, with femtosecond time resolution. In particular, FELs strongly enhanced the capabilities of several analytical techniques, which took advantage of the high degree of transverse coherence provided. FELs based on the harmonic up-conversion of an external seed laser are characterised also by a high degree of longitudinal coherence, since electrons inherit the coherence properties of the seed. At the present state of the art, the shortest wavelength delivered to user experiments by an externally seeded FEL light source is about 4 nm. We show here that pulses with a high longitudinal degree of coherence (first and second order) covering the water window and with photon energy extending up to 790 eV can be generated by exploiting the so-called nonlinear harmonic regime, which allows generation of radiation at harmonics of the resonant FEL wavelength. Moreover, we report the results of two proof-of-principle experiments: one measuring the oxygen K-edge absorption in water ( $\sim 530$  eV), the other analysing the spin dynamics of Fe and Co through magnetic small angle x-ray scattering at their L-edges (707 eV and 780 eV)

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Yes

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