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Recent experimental results from FLASH2 on novel FEL lasing schemes with variable gap undulators

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We discuss principles and experimental verification of advanced schemes for X-ray FELs using variable gap undulators (harmonic lasing self-seeded FEL, reverse taper etc.). Harmonic lasing in XFELs is an opportunity to extend operating range of existing and planned X-ray FEL user facilities. Contrary to nonlinear harmonic generation, harmonic lasing can provide much more intense, stable, and narrow-band FEL beam which is easier to handle due to the suppressed fundamental. Another interesting application of harmonic lasing is Harmonic Lasing Self-Seeded (HLSS) FEL that allows to improve longitudinal coherence and spectral power of a SASE FEL. Recently this concept was successfully tested at FLASH2 in the wavelength range between 4.5 nm and 15 nm. That was also the first experimental demonstration of harmonic lasing in a high-gain FEL and at a short wavelength (before it worked only in infrared FEL oscillators). Another interesting scheme that was tested at FLASH2 is the reverse tapering that can be used to produce circularly polarized radiation from a dedicated afterburner with strongly suppressed linearly polarized radiation from the main undulator. Reverse tapering can also be used to produce background-free harmonics in the afterburner. An application of frequency doubling that allowed to reach the shortest wavelength at FLASH is discussed as well.

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