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Photocathode Laser for X-ray FELs at DESY with Flexible Pulse Shape

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The photocathode laser plays an important role for X-ray Free Electron Laser (XFEL) operation since the generated electron clouds at the gun determine many of the X-ray parameters. Its energy and pointing stability is a pre-requisite for stable X-ray pulse trains. The XUV FEL FLASH at DESY runs in burst-mode, where XUV pulses are emitted in 800 µs long bursts with up to 1MHz intra-burst pulse-repetition rate and 10 Hz burst repetition rate. Each burst of accelerated electron bunches is temporal split into two undulator beamlines, each of them serving multiple science experiments.
Different FEL operation modes require optimized electron charge distributions at the electron gun and therefore different photocathode laser pulse shapes. Two extreme requirements are (1) large flat-top beam sizes with long pulse durations (20 ps) for high X-ray pulse energies and (2) short pulse duration (1 ps), small beam sizes for the shortest X-ray pulses (10fs). Currently those different pulse durations are realized by separate photocathode laser systems. Here we present a new photocathode laser design, providing flexible UV pulse durations from 1 ps to 20 ps and single pulse 257nm pulse energies up to 10 µJ at 1 MHz pulse repetition rate.

Summary

Novel operational regimes of X-ray Free-Electron Lasers (XFELs) require advanced laser systems offering a high degree of flexibility of their output pulse parameters. In our case, the photocathode laser, which generates electrons from a RF photocathode gun, defines the efficiency and flexibility of the XFEL. Thus full control of the spatial (flat-top or truncated Gaussian) and temporal shape (Gaussian or temporal flat-top: 1 ps –20 ps) of the deep UV laser pulses is a powerful tool to tailor the charge, size and length of the generated electron bunches for optimal emittance. In this submission a burst-mode photocathode laser for the soft-X-ray FLASH XFEL and the hard-X-ray European XFEL in Hamburg, Germany is presented, which can deliver pulses with flexible duration from 1 ps to 20 ps and single pulse energies up to 100 µJ in NIR (expected > 10µJ DUV) at an pulse repetition rate of up-to 1 MHz in up to 1 ms long bursts at 10 Hz burst-repetition rate.

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