Contribution ID: **41** Type: **Poster**

Scaling EUV and X-ray Thomson Sources to Optical Free-Electron Laser Operation with Traveling-Wave Thomson-Scattering

Tuesday 5 March 2019 17:20 (3 minutes)

Traveling-Wave Thomson-Scattering (TWTS) is a novel Thomson scattering geometry which allows for orders of magnitude higher photon yields than classic head-on Thomson sources. TWTS thereby remains compact and provides narrowband and ultra-short ultraviolet to γ-ray radiation pulses just as classic Thomson sources. Even the realization of optical free-electron lasers is possible with the TWTS geometry since it provides both optical undulators with thousands of periods needed to microbunch the electron beam and a reduction of electron beam quality requirements compared to classic Thomson scattering to a level technically feasible today.
TWTS employs a side-scattering geometry depicted in fig. 1. Laser and electron propagation direction of motion enclose the interaction angle ϕ. Tilting the laser pulse front with respect to the wave front by half the interaction angle ensures continuous overlap of electrons and laser pulse over the whole laser pulse width while the laser pulse crosses the electron beam trajectory. In this way the interaction length becomes controllable by the laser pulse width and independent of the laser pulse duration. Utilizing wide, petawatt class laser pulses for TWTS allows to realize thousands of optical undulator periods.
The variability of TWTS with respect to the interaction angle can be used to control the radiation wavelength even for electron sources with fixed energy. For a fixed target wavelength on the other hand, the free choice of interaction angle enables control over electron beam quality requirements. Small interaction angle scenarios (ϕ~10°) typically yield the best trade-off between requirements on electron beam quality, laser power and laser intensity stability.
In the talk we will show that TWTS OFELs emitting extreme ultraviolet radiation are realizable today with existing technology for electron accelerators and laser systems. We detail an experimental setup to generate the tilted TWTS laser pulses which aims at compactness and provides focusing of these high-power pulses and compensation of dispersion accompanying pulse-front tilts. The method presented for dispersion compensation is especially relevant when building high yield X- and γ-ray sources in large interaction angle setups of TWTS.

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Session Classification: Poster Session

Track Classification: ARD