Laser Requirements for Efficient X-Ray Generation by Relativistic Electron Spikes

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High-order harmonics from relativistic electron spikes [1, 2] are a source of bright coherent x-rays produced by multi-terawatt relativistic-irradiance (>10^{18} W/cm^2) femtosecond lasers focused onto gas jet targets. Our experiments with the J-KAREN laser [3] demonstrate that the harmonics generation efficiency strongly depends on laser pulse quality and in particular on the focal spot shape. Here we establish requirements for the high-power laser needed for efficient harmonics generation. Specifically, the focal spot should be close to a diffraction-limited shape with the Strehl ratio greater than 0.5. This requires a rms wavefront error of much smaller than 100 nm, assuming a noise-like high-frequency wavefront error distribution. In addition, the angular dispersion must be kept smaller than a fraction of the diffraction divergence. For typical 100 to 300 mm diameter high-power laser beams, this requires angular dispersion below the μrad level, i.e. < 10^{-2} μrad/nm angular chirp for typical 50 nm bandwidths.

1. A. S. Pirozhkov, *et al.*, "Soft-X-Ray Harmonic Comb from Relativistic Electron Spikes," *Phys. Rev. Lett.* **108** (13), 135004-5 (2012).
2. A. S. Pirozhkov, *et al.*, "High order harmonics from relativistic electron spikes," *New J. Phys.* **16** (9), 093003-30 (2014).
3. H. Kiriyama, *et al.*, "High-Contrast, High-Intensity Petawatt-Class Laser and Applications," *IEEE J. Sel. Topics Quantum Electron.* **21** (1), 1601118-18 (2015).