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Brilliant X-Ray Free Electron Laser Driven by Resonant Multi-Pulse Ionization Injection Accelerator

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Laser Wakefield Accelerators are now sufficiently mature to provide GeV scale/high-brightness electron beams capable of driving Free Electron Laser (FEL) sources. Here, we show start-to-end simulations carried out in the framework of the EuPRAXIA project of a Free Electron Laser driven by an LWFA accelerator in the Resonant Multi-Pulse Ionisation Injection (ReMPI) framework. Simulations with this model using a 1 PW Ti:Sa laser system and a 20 cm long capillary, show the injection and acceleration of an electron beam up to 4.5 GeV, with a slice energy spread and a normalized emittance below 4×10^{-4} and 80 $nm \times rad$, respectively. The transport of the beams from the capillary exit to the undulator is provided by a matched beam focusing with a marginal beam-quality degradation. Finally,
3D simulations of the FEL radiation generated inside an undulator show that $\approx 10^{10}$ photons with central wavelength of $0.15\,nm$ and peak power of $\simeq 0.3\,GW$ can be produced for each bunch. Our start-to-end simulations indicate that a single-stage ReMPI accelerator can drive a high-brightness electron beam having quality large enough to be efficiently transported to a FEL undulator, thus generating X-ray photons of brilliance exceeding $10^{25} ph/s/mm^2/0.1\%bw$

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