Contribution ID: **232** Contribution code: **WECI1** Type: **Invited Orals**

Free-Electron Lasing Based on a Laser Wakefield Accelerator

Wednesday, 24 August 2022 14:10 (30 minutes)

Laser wakefield accelerators can sustain accelerating gradients more than three orders of magnitude higher than those of radio-frequency accelerators, and are regarded as an attractive option for driving compact X-ray free-electron lasers. However, the realization of such devices remains a challenge owing to the relatively poor quality of electron beams that are based on a laser wakefield accelerator. After ten years of efforts, we present an experimental demonstration of undulator radiation amplification in the exponential-gain regime by using electron beams based on a laser wakefield accelerator. The amplified undulator radiation, which is typically centred at 27 nanometres and has a maximum photon number of around 1010 per shot, yields a maximum radiation energy of about 150 nanojoules. The results constitute a proof-of-principle demonstration of free-electron lasing using a laser wakefield accelerator, and pave the way towards the development of compact X-ray free-electron lasers based on this technology with broad applications. In future, a laboratory-scale, ultra-brilliant FEL (around 10 m in size), with the advantages of low cost (˜US$5 million), high temporal resolution (femtosecond-level), high resolution (nanometre-level), and ultra-high precision timing control (less than 1 fs), could gain popularity.

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Session Classification: Novel acceleration and FEL concepts

Track Classification: Novel acceleration and FEL concepts