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Recent progress in the LWFA-driven COXINEL FEL and its prospect towards shorter wavelengths lasing

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Laser-plasma electron acceleration hit a turning point by the recent demonstrations of plasma-wakefield-driven FEL. Yet, there are still the remaining challenges to be resolved before such compact light sources ready for user applications. We present recent progress made by the HZDR-SOLEIL collaboration in seeded FEL using the COXINEL FEL-line powered by the HZDR laser-plasma accelerator. This platform facilitates a comprehensive and structured approach to the development of key components covering high-quality electron beam generation, advanced plasma-beam diagnostics and control, electron beam transport and FEL physics, all integrated in one laboratory. In particular, by exploiting strongly chirped electron beams, a new FEL scheme with red-shifted lasing was demonstrated, its spectral tunability was studied, while a careful analysis of the shape of the interference pattern of seed and FEL light revealed novel insight into the FEL process. Recent results on the LWFA stage show higher spectral-charge-density beyond 10 pC/MeV at improved stability aided with machine-learning-based optimization methods. Together with better control on beam phase-space during transport and on seed laser, higher FEL output of up to 50 nJ/pulse is achieved, well matching with simulations. This good agreement between experiments and simulations allows for parameter scaling towards shorter wavelengths down to EUV range.

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