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Seeded Free Electron Lasers: The Technical Challenges and the Scientific Impact

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The fields of laser and accelerator technology stand now at a point of remarkable opportunity—the creation of fully coherent and powerful pulses of x-ray radiation ranging in wavelength from 100 nm to 0.1 nm. Radiation in this essential wavelength range is unlikely to be produced with substantial power, particularly below wavelengths of 10nm, by table-top laser sources. Sources based solely on circular accelerators, such as synchrotrons and energy-recovery linacs, cannot achieve full coherence. Even the current generation of free-electron lasers (FELs) based on self-amplified spontaneous emission (SASE) expect to produce less than 1% of the power in a single mode in their baseline designs. The key to achieving full transform-limited coherence is to imprint the electron bunch with a fully coherent seed pulse generated by either an external source or by clever manipulations of the FEL radiation itself. We will review the technological challenges presented by this approach in the context of efforts such as the Trieste FERMI project, and a major new soft x-ray/VUV FEL user facility being studied for the University of Wisconsin. Further, we will summarize the impact of such a source in various areas of science