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Ultra-compact X-ray FEL Based on Advanced Cryogenic RF techniques

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Recent advances in high gradient cryogenic copper structures RF research have opened the door to a use of surface electric fields between 250 and 500 MV/m. Such structures can be used to enable a new generation of photoinjectors with brightness an order of magnitude beyond the state-of-the-art. In addition, one may accelerate these beams to GeV scale in <10 m. Such an injector, when combined with ESASE bunching techniques can produce multi-kA beams with ~50 nm-rad emittance. These beams, when injected into innovative, short-period (1-10 mm) undulators based on advanced manufacturing technique enable ultra-compact X-ray FELs having footprints consistent with university-scale laboratories. We discuss the design and performance of this novel light source, which promises photon production per pulse of a few percent of existing XFELs. In the context of a nascent project on UCLA to develop this instrument, we review implementation issues including collective beam effects, compact X-ray optics systems, and various technical challenges. To illustrate the potential of such a light source to fundamentally change the current paradigm of XFELs with their limited access, we examine possible applications in biology, chemistry, materials, and atomic physics which may take advantage of this new model of performing XFEL science.

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