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Undulator Models for Ray-Tracing Simulations

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Undulators serve as the primary magnetic structures for generating synchrotron radiation in third and fourth-generation sources. The emitted radiation from undulators is intricate, featuring spectrum peaks at specific photon energies (resonances), and the
beam geometry is notably influenced by the photon wavefront and emittance of the storage ring. Various software tools exist for assessing undulator radiation characteristics. Ray-tracing packages, for instance, construct undulator sources by sampling rays
according to distributions prescribed by undulator theory.

In this work, we present the models and algorithms utilized for simulating undulators in the new SHADOW4 package. While SHADOW has included an undulator model [1] since its conception, certain neglected effects, inconsequential for second-generation synchrotron sources, have gained significance in modern low-emittance storage rings
and fourth-generation sources. Notably, the consideration of photon source size, encompassing diffraction limit effects, and the impact of electron energy spread in high harmonic undulator operation. The SHADOW4 undulator sources now boast a range of enhancements and novel features.

The “Gaussian undulator” application, for instance, generates a source with rays conforming to Gaussian distribution, approximating undulator distributions with varying degrees of accuracy. This has been found very useful when in a first phase or prototyping beamlines using undulators as sources. The introduction of SHADOW4[2], a refactored, and refurbished version of this popular ray-tracing code, has facilitated the reimplementation, refinement, rectification, and augmentation of undulator algorithms, enhancing simulation performance and accuracy.

Here we describe the methods and algorithms used in SHADOW4 for simulating undulator sources. We first summarize the most important results of the undulator theory used, with a detailed discussion of the Gaussian approximations for beam sizes and divergences. Then, the algorithms and ideas used for sampling the rays of the
undulator sources, in the Gaussian approximation and the full model, are described. Finally, some examples and discussion are presented.

References

[1] K Chapman, B Lai, F Cerrina, and J Viccaro. Modelling of undulator sources. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 283(1):88–99, 1989. https://doi.org/10.1016/0168-9002(89)91260-6

[2] M. Sanchez del Rio and L. Rebuffi. 40 years of shadow: Serving four generations of synchrotron facilities. Synchrotron Radiation News, 36(5):6–7, 2023. https://doi.org/10.1080/08940886.2023.2274745

I plan to submit also conference proceedings

Yes

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