Contribution ID: **103** Type: **Contributed talk**

High Accuracy Simulations of Extreme Polarization Purity of a X-ray Beam for Brewster Crystal Diffraction

Tuesday 27 August 2024 17:30 (15 minutes)

Xiaojiang Yu^a, *Lingang Zhang^b, Liangliang Ji^b, Xiao Chi^c, A. T. S. Wee^c, Mark B H Breese^{a,c}, M.Sanchez del Rio^d*</sup>

^aSingapore Synchrotron Light Source, National University of Singapore, 5 Research Link, Singapore 117603, Singapore
^bState Key Laboratory of High Field Laser Physics and CAS Center for Excellence in Ultra-intense Laser Science, Shanghai Institute of Optics and Fine Mechanics (SIOM), Chinese Academy of Sciences (CAS), Shanghai 201800, China
^cDepartment of Physics, National University of Singapore, Singapore 117576, Singapore
^dEuropean Synchrotron Radiation Facility, 38000 Grenoble, France
*Correspondence e-mail: slsyxj@nus.edu.sg, srio@esrf.eu

Vacuum birefringence which is predicted by quantum electrodynamics (QED) has attracted more attention in recent years, due to advances in the development of powerful pump optical lasers (pump) and X-ray free electron lasers (XFEL) (probe) [1]. The head-on collision between the pump laser and probe XFEL will result in diffraction of X-rays and polarization-flipping for a trivial number of photons [2], which is around 10 billionth at the present power density level of optical laser and XFEL. Flipping changes the polarization of X-rays from linear to elliptical with ellipticity of around 1E-10 [3]. For experiments to verify such ellipticity, the linear polarization purity of the X-rays is required to be less than 1E-10. Several four-bouncing crystal monochromators (polarizers) working at the Brewster angle of 45 are proposed, which only deflect -polarization with -polarization being suppressed. However, the polarization purity is dependent on both the divergence and energy bandwidth of the X-ray beam impinging on the polarizer. The purity limit is given by an empirical formula which is estimated by the Gaussian divergence of the X-ray beam [4]. Nevertheless, the X-ray beam may slightly depart from a Gaussian profile due to beamline optical focusing and the bandwidth may not be accounted for properly in the formula, which may be not sufficient for extreme ellipticity. In this paper, we describe upgrades to the SHADOW [5,6] code to give high accuracy simulations for linear polarization of an X-ray beam after Brewster deflection. Treating the real divergence as well the bandwidth in the simulation has not previously been done. We present the simulation for a XFEL beamline optics with linear purity around 1E-11. It will give an alternative way to understand the linear purity in the future experiments.

References
1 W. Decking, et al, Nat. Photonics 2020 146 14(6), 391–397 (2020).
2 E.A. Mosman, et al,Phys. Rev. D 104(1), 1–11 (2021).
3 B. Shen, et al. Exploring Vacuum Birefringence Based on a 100 PW Laser and an X-Ray Free Electron Laser Beam, Plasma Phys. Control. Fusion 60, 044002 (2018).
4 K.S. Schulze, et al, APL Photonics 3(12), 126106–1 (2018).
5 M. Sanchez Del Rio, J. Synchrotron Radiat. 18(5), 708–716 (2011).
6 X.J. Yu, et al, J. Synchrotron Radiat. 29, 1157–1166 (2022).

I plan to submit also conference proceedings

Yes

Primary authors: Dr YU, Xiaojiang (Singapore Synchrotron Light Source, National University of Singapore, 5 Research Link, Singapore 117603, Singapore); Prof. RIO, M.Sanchez del (European Synchrotron Radiation Facility, 38000 Grenoble, France)

Co-authors: Prof. ZHANG, Lingang (State Key Laboratory of High Field Laser Physics and CAS Center for Excellence in Ultra-intense Laser Science, Shanghai Institute of Optics and Fine Mechanics (SIOM), Chinese Academy of Sciences (CAS), Shanghai 201800, China); Prof. JI, Liangliang (State Key Laboratory of High Field Laser Physics and CAS Center for Excellence in Ultra-intense Laser Science, Shanghai Institute of Optics and Fine Mechanics (SIOM), Chinese Academy of Sciences (CAS), Shanghai 201800, China); Dr CHI, Xiao (Department of Physics, National University of Singapore, Singapore 117576, Singapore); Prof. WEE, A. T. S. (Department of Physics, National University of Singapore, Singapore 117576, Singapore); Prof. BREESE, Mark B H (Singapore Synchrotron Light Source, National University of Singapore, 5 Research Link, Singapore 117603, Singapore)

Presenter: Dr YU, Xiaojiang (Singapore Synchrotron Light Source, National University of Singapore, 5 Research Link, Singapore 117603, Singapore)

Session Classification: Mikrosymposium 1/2: Beamline Optics and Diagnostics

Track Classification: 1. Beamline Optics and Diagnostics