Inverse Compton Scattering X-ray Source for Research, Industry and Medical Applications

Benjamin Hornberger, Jack Kasahara

Lyncean Technologies, Inc., 47633 Westinghouse Dr., Fremont, CA 94539, USA
benjamin_hornberger@lynceantech.com

There is a large performance gap between conventional, electron-impact X-ray sources and synchrotron radiation sources. An Inverse Compton Scattering (ICS) X-ray source [1,2] can bridge this gap by providing a narrow-band, high-flux and tunable X-ray source that fits into a laboratory at a cost of a few percent of a large synchrotron facility. It works by colliding a high-power laser beam with a relativistic electron beam, in which case the energy of the backscattered photons is in the X-ray (or gamma-ray) regime. So far, the only ICS source in regular user operation is the Munich Compact Light Source (MuCLS) [3], a combination of Lyncean Technologies' commercially available Compact Light Source (CLS) [4] and a beamline with two endstations built by researchers at the Technical University of Munich [5]. The application focus of the MuCLS is biomedical imaging of centimeter-sized samples in the 15-35 keV energy range, well-matched to the beam properties of the Lyncean CLS with ~4 mrad divergence and spectral bandwidth of 3-5%.

Here we present a concept for an ICS X-ray source that is about two orders of magnitude brighter than the existing CLS design. Depending on configuration, it covers an X-ray energy range of about 30-90 keV, or 60-180 keV. It will provide X-ray flux of up to 10^{13} photons/s within a beam divergence of 4 mrad and a bandwidth of around 10%. This is well-suited for high resolution, micro-CT imaging of millimeter-sized samples at micron resolution, with a flux density similar to some high-energy synchrotron beamlines. The beam properties of the new design are also compatible with focused beam applications such as high-energy diffraction, since using a lower divergence part of the beam with lower bandwidth allows the use of several types of X-ray optics commonly used at synchrotron beamlines.

In this presentation, we will discuss the novel concepts applied to the design of this X-ray source as well as the resulting beam properties. We will discuss several application examples in the areas of imaging, diffraction and radiotherapy where this system can approach or meet the performance of synchrotron beamlines. This will allow transferring many industrial, research and medical applications from the synchrotron, where capacity is limited, to a local lab or clinic.

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[2] M. Jacquet, "Potential of compact Compton sources in the medical field," *Phys Medica* 32, 1790-1794 (2016).
[3] E. Eggl, M. Dierolf, K. Achterhold *et al.*, "The Munich Compact Light Source: initial performance measures," *J Synchrotron Radiat* 23, 1137–42 (2016)
[4] B. Hornberger, J. Kasahara, M. Gifford *et al.*, "A compact light source providing high-flux, quasi-monochromatic, tunable X-rays in the laboratory," Advances in Laboratory-based X-Ray Sources, Optics, and Applications VII, A. Murokh and D. Spiga, Eds., 2, SPIE, San Diego, United States (2019).
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