Beam Diagnostics of X-ray Free Electron Laser by Imprinting X-ray Vortex

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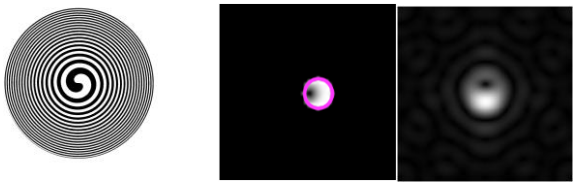
Abstracts: *We here propose a method to emphasize the motion of the x-ray beam by constructing a phase sensitive system where an x-ray vortex is imprinted. We will also report on our successful demonstration to retrieve the wave front at the focused x-ray vortex beam by analyzing one interferogram obtained in two-beam interferometry.*

XFEL radiation is formed by the Self Amplified Spontaneous Emission (SASE). To improve the x-ray beam stability for precise scientific measurements, the development of x-ray beam diagnostics is an urgent issue. SACLA facility already provides efficient diagnostic tag database on x-ray energy, position, and total energy of pulse. The remaining issue is to improve the stability of the x-ray beam by clarifying the nature of its oscillation. We here propose a method to sensitively monitor the x-ray beam motion by generating a focused x-ray beam with a vortex and use a pinhole as a spatial filter. The center of the optical vortex is characterized by a zero-intensity dark spot and the spiral phase structure with a jump equaling multiples of 2π.

We devised a diagnostic method where we set a spatial filter, a pinhole, at the focal plane of Spiral Fresnel Zone Plate (SFZP, Fig. 1, [1]). We designed a SFZP having a zone with a depth for the phase shift of π and the destructive interference. By recording the diffraction pattern of the pinhole by a downstream x-ray image sensor, the motion of the x-ray beam position and tilt is extracted. During the beam oscillation, the dark spot inside the diffraction pattern shifts by a significant amount due to the eccentricity of the vortex core from the center of pinhole. We will show how effectively the x-ray beam is diagnosed using simulations and experiment at SACLA.

As the next topic, we demonstrate that the wave front at the focal plane of SFZP is retrievable by analyzing one interferogram obtained in two–beam x-ray interferometry at SPring-8 undulator beamline. Using the Fourier-transform method on one x-ray interferometric pattern, we observed a spiral phase structure with a 2π jump at the focal plane. This proves that x-ray interferometry would be powerful in XFEL studies.

[1] A. Sakdinawat et al., *Opt. Lett.* 32, 2635, 2007



(a) (b) (c)

Fig.1. (a)Schematic diagram of SFZP. (b) The transmitted amplitude distribution through a pinhole. (c) The simulated diffraction pattern at the detector plane.