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Scattering effect from mirror surface defects: analytical and simulation approach

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The scattering properties of mirror surfaces are strongly dependent on the surface structure and radiation incidence angle, for a given photon energy. In particular, in Free Electron Laser and Synchrotron X-ray photon transport beamlines, the perturbation of the scattering effect is often dominant in the Point Spread Function (PSF) degradation. The perturbation theory explains the surface Power Spectral Density (PSD) - scattering link, its main result being a simple linear relationship between the scattered intensity distribution and the PSD, expressed as a function of the surface spatial wavelength. The PSD can be assembled from various surface profile measurements, such as optical interferometry, profilometry, and Atomic Force Microscopy. Mathematically, the PSD is the square of the surface profile's Fourier transform, or, equivalently, the Fourier transform of the auto-covariance function of the surface profile. Given the PSD of a non-ideal mirror surface, the mathematical form of the observed scattering is provided by the well-consolidated first-order perturbation theory.

The present work discusses the degradation of the PSF due to the scattering in grazing incidence geometry, from Extreme Ultra Violet to Hard X-ray photon energies. We analyzed a simple optical system constituted by a plane mirror and a set of Kirkpatrick-Baez plane-elliptical mirrors, taking into account the complete PSD of the mirrors.
The issue is discussed by comparing a first-order scattering theoretical approach and simulations performed with SHADOW (raytracing), Synchrotron Radiation Workshop (SRW, wave optics based), WISEr (wave optics based), and SHADOW's Hybrid extension. The results obtained should be useful in facing this issue.

Journal of Synchrotron Radiation Special Issue: will you submit your contribution?

yes

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