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► **To cite this version:**

Emilie Pietersoone, Jean Michel Létang, Simon Rit, Emmanuel Brun, Julien Bert, et al.. Refraction simulation for optimisation of X-Ray Phase Contrast imaging. XRM2024, Aug 2024, Lund, Sweden. hal-04910272

HAL Id: hal-04910272

<https://hal.science/hal-04910272v1>

Submitted on 24 Jan 2025

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Refraction simulation for optimisation of X-Ray Phase Contrast imaging

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Keywords: X-ray Phase Contrast Imaging, Refraction, Simulation; (maximum 4)

X-ray Phase Contrast Imaging (XPCI) is particularly advantageous when imaging materials with low X-ray absorption. This technique provides superior visualisation compared to absorption-based methods. The phase information obtained through XPCI's exploitation of refraction is highly sensitive to changes in the sample's electron density. Current XPCI simulation methods, while valuable, fail to recreate the noise present in experimental images. The current hypothesis, is that it might be due to limitations in capturing certain physical phenomena [1]. Some simulation methods combine MC and wave effects in order to include refraction [2,3]. The presented research continues this research, by testing different methods to incorporate refraction in 2D and 3D projection-based simulations.

We focus on edge detection [4] within a ray tracing projection-based simulation. The research is based on the application of Snell's law at the sample interfaces. Detection of these interfaces are done by testing both gradient calculation and application of thresholds, and use of the monogenic signal to analytically calculate the trajectory for multidimensional signals [5]. The gradient module quantifies the importance of the highlighted contour, which is the magnitude of the intensity jump observed in the image. The gradient direction determines the edge present in the image. Indeed, the gradient direction is orthogonal to that of the contour. The monogenic signal is seen as an extension of the analytic signal, transitioning from one-dimensional to high-dimensional space. It is constructed by combining the Riesz transform with the original signal, offering representations of signal features like local attenuation and the local phase vector. The motivation comes from providing a framework to include incoherent scattering in XPCI simulations. The different methods that will be presented compare a theoretical result with a prism, a gradient orientation-based method, and a monogenic signal-based method. Purpose of the method, is proposing a novel manner of including refraction for voxels.

X-ray phase contrast techniques have shown promise for improving soft tissue visibility and enhancing the detection of subtle abnormalities. Simulations incorporating refraction participate in optimising the imaging setup for specific applications, contributing to the development of more effective diagnostic tools. XPCI is invaluable in material science and non-destructive testing by providing detailed information about the internal structures of materials. Refraction simulations are crucial for understanding and optimizing the imaging process for different types of materials.

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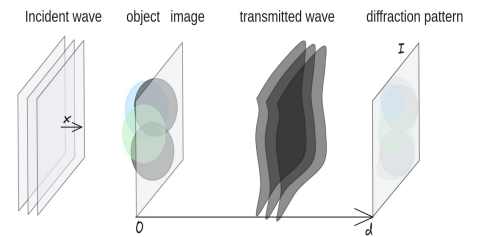


Figure 1: Physical model of propagation-based XPCI. Incident plane waves (x) are scattered by an object, imprinting a phase and absorption image on the transmitted wave-fronts. The intensity (I) is recorded at a distance (d).

(1 page limit, including everything)