Using GPU Computing techniques to enhance Phase-Retrieval Algorithms in Edge Ilumination Methods for X-ray Phase Contrast Imaging.

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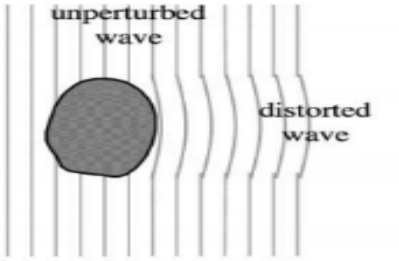
What is X-Ray Phase Contrast Imaging?

X-rays are massless particles of light called photons that propagate via electromagnetic waves. When X-rays travel through a material they attenuate. The material also refracts the x-rays such that different photons at different locations are at different phases in their electromagnetic wave oscillation. The result is a wave with distorted wave fronts.



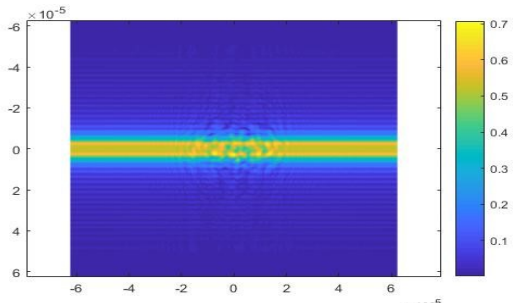
X-ray contrast Imaging (XPCI) utilizes these phase differences to obtain images containing structural information of the material that otherwise could not be obtained using conventional attenuation based imaging. Thus the Refractive Index of a material for X-rays is given by:

$$n = 1 - \delta + i\beta$$

Beta accounts for the attenuation effects whereas the Delta accounts for the phase shifts in the x-rays.

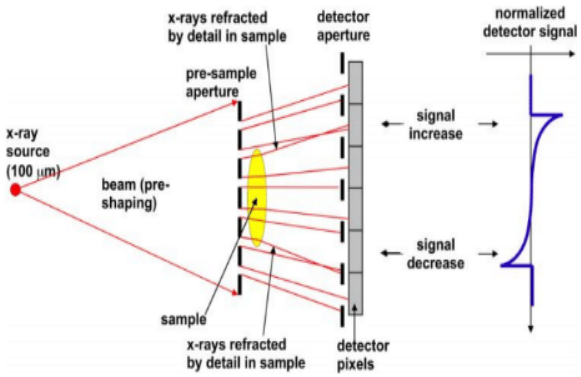
Single Slit Multisphere X-Ray Scattering

In my project I was tasked to create a code that would calculate the x-ray scattering and diffraction patterns caused by microspheres made out of titanium dioxide inside a silicone cube. Using Matlab I created different densities of scattering microspheres, as well as different sized microspheres. Then I used them to calculate the x-ray diffraction patterns at different photon energies. The figure below is one such pattern:



Edge Illumination Principle

The Edge Illumination Principle (EIP) is a method to obtain phase contrast in a material due to x-ray refraction. Since x-ray refraction angles are usually very small (microradians), this method is able to record small deviations in intensity signals that arise from these small refraction angles.



The figure above illustrates the EIP setup. A pre-sample aperture splits the synchronous, monochromatic x-ray source into various beamlets. The detector aperture is slightly misaligned so that every beamlet hits the edge of an aperture on the detector mask. Thus the intensity signal of x-rays in the detector pixels correlates to the refraction angles caused by the material. A 2D image is formed by scanning the sample along its height.

GPU Computing in XPCI Algorithms

Using Matlab´s built in functions for parallel computing , I stored critical variables in phase retrieval algorithms used in XPCI in the graphic driver cards of the computer. The Graphic Processing unit of the computer made all the necessary computations in a shorter amount of time to retireve the x-ray diffraction patterns required to form the phase contrast images.However it only became faster than the central processing unit when the amount of computations reached a threshold. In other word when the amount of microspheres reached a certain number.