New algorithm for wave propagation and phase retrieval in Fresnel diffraction to extract x-ray images

The success of materials science today is largely based on x-ray diffraction from crystalline materials. However, not all materials of interest are in crystalline forms; examples include the majority of membrane proteins and many nanostructure specimens at their functioning levels. For these noncrystalline specimens, imaging at high spatial resolution offers the only alternative to obtain information on their internal structures. This work describes extending Fresnel theory to retrieve phase information needed for full image reconstruction. Although this algorithm was developed for coherent x rays, the distorted-object concept can be universally applied to other diffraction and imaging fields such as using visible light, electrons, and neutrons. These results will stimulate further developments in the area of diffractive imaging for high-resolution structural studies of noncrystalline materials.

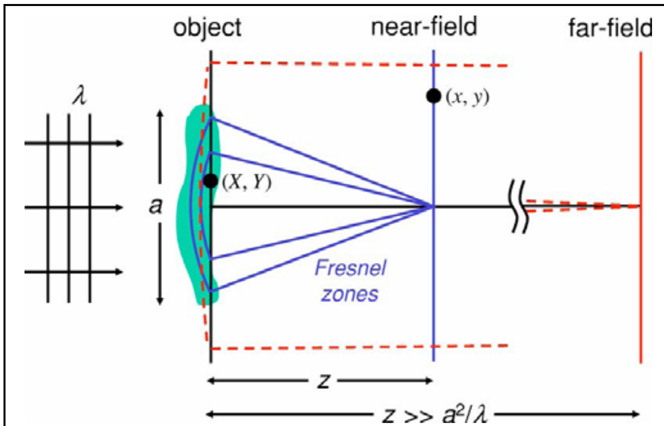

Illustration of coherent x-ray wave propagation with a distorted object approach both for the near-field Fresnel diffraction, where an object extends into multiple Fresnel zones solid lines and for the far-field Fraunhofer diffraction, where an object occupies only the center of the first Fresnel zone dashed lines.

This work is notable because it demonstrates an algorithm for 3-dimensional full field imaging with x-rays. This might prove vital for nanoscale materials imaging, and is especially important to utilize future x-ray sources that have fully coherent photon beams. With a wavelength of 0.1 nanometer, x-ray imaging has great potential for a wide variety of applications in nanoscale materials – from hard materials sciences to biomaterials.

See also:

CHESS Newsletter 2005 article here.
Also: Phys. Rev. B **72**, 033103 (2005) and PDF.