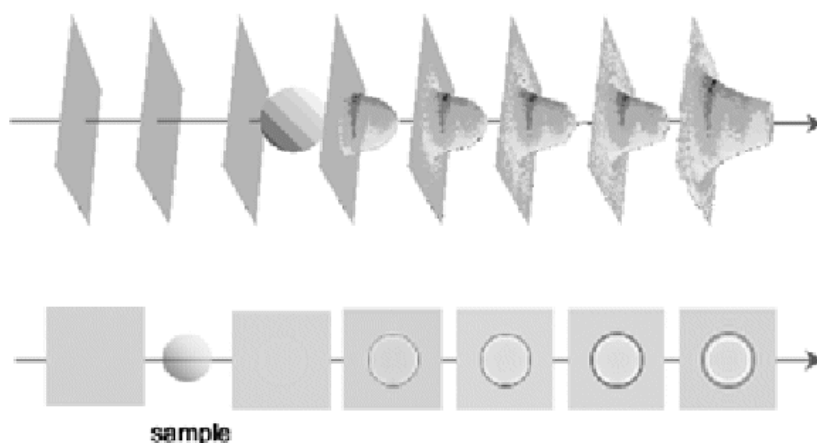


Phase retrieval as a means of restoring resolution

A number of postprocessing algorithms have been developed, all of which aim to extract the phase or the phase and amplitude distribution of the X-rays immediately after passing through the object. The X-ray phase shift caused by the object is proportional to the projected electron density along the X-ray path. Extracting this phase shift, therefore, gives quantitative information about the object. In the case of a single component object the phase shift is proportional to the thickness.



The phase extraction algorithms reconstruct the phase (and in some cases, the amplitude) of the transmitted X-ray beam from one or more inline X-ray images collected at one or more sample-to-detector distances, at one or more X-ray wavelengths. The phase distribution is ideally assumed to be the result of the transmission of a plane (spatially coherent) monochromatic (temporally coherent) incident wave through an object, and the image registered by a position-sensitive detector (i.e. a CCD). In the X-ray system, the incident X-ray wave front is nominally spherical (from a point source) and polychromatic (non temporally coherent), but these limitations can be overcome with simple preprocessing (rescaling and renormalization) of the images prior to applying the algorithms. The retrieved phase is directly proportional to the projected electron density in the sample. The images used in the algorithms must be collected in the near-field region defined by the inequality

$$NF \equiv h^2/(\lambda R') \gg 1$$

where h is the size of a feature being imaged, λ is the X-ray wavelength, R' is the defocus distance, ($R' = R_1 R_2 / (R_1 + R_2)$), and NF is the Fresnel number. In this regime, the image appears to be a simple 'edge-enhanced' representation of the object. Different methods (e.g. combinations of the algorithms with Gerchberg-Saxton-type phase refinement procedures) are needed for images collected in the intermediate (Fresnel, $NF \cong 1$) or far (Fraunhofer, $NF \ll 1$) field, respectively). The algorithms also require knowledge of the physical dimensions (size) of the images, the X-ray wavelength(s) and the defocus distance R' . All values should be expressed in microns. All of the algorithms attempt to reconstruct the phase (and some of them also attempt to reconstruct the amplitude) of the transmitted X-ray beam from one or more in-line X-ray images collected at one or more sample-to-detector distances at one or more X-ray wavelengths.