Phase Retrieval in Tomography with Kirkpatrick-Baez Mirrors

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Two x-ray mirrors reflecting in planes perpendicular to each other and bent to the desired elliptical shape produce a two-dimensional focus when placed in the parallel beam of a synchrotron source. A graded multilayer on the first mirror acts as broadband monochromator ($\Delta E/E = 10^{-2}$) and provides a very high flux (up to 10^{12} ph/s). We obtain a focal spot of 100 nm in vertical and horizontal direction, thus opening possibilities for various imaging techniques at a new level of spatial and temporal resolution.

Magnified radiographs can be obtained by putting the sample a small distance downstream (or upstream) of the focus and the detector at a large multiple of the sample to focus distance. The defocusing distance and magnification can be changed by translating the sample in the direction of the x-ray beam while keeping the detector fixed. The recorded images correspond to the Fresnel diffraction regime and a phase retrieval step has to be associated to the tomography in order to obtain interpretable information and optimum resolution.

One limitation of tomography with the KB system is due to mirror shape imperfections, leading to a sample illumination which is not a simple spherical wave. We propose an image correction method based on the knowledge of the distortion introduced by the two mirrors. The latter information is obtained by employing a grid as a wavefront sensor. Before phase retrieval itself can be performed another crucial step is to bring the radiographs at all planes to the magnification of the plane closest to the focus and to precisely align them relative to each other. Finally, different phase retrieval methods are compared on experimental data. Astonishingly, the best results are obtained when the samples are much larger than the field of view (local tomography (see Fig.1)).

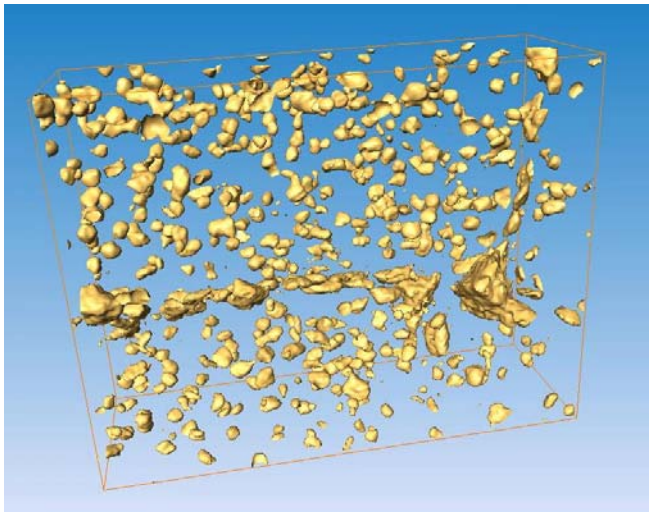

Figure 1: Resulting 3D image of an Al-Cu alloy near a grain boundary