Computed Tomography of a rapidly-frozen yeast cell using Ptychographic Coherent X-ray Diffractive Imaging

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The goal of this experiment was to image a single plunge-frozen yeast cell under cryogenic conditions using Ptychographic Coherent X-ray Diffractive Imaging (PCDI), in three dimensions.

The experiment was performed at the P10 beamline of the PETRA III synchrotron at DESY, using the Göttingen Instrument for Nano-Imaging with X-rays (GINIX) [1], a modular setup installed at the P10 beamline. For a schematic of the experimental setup as used here see Fig. 1. The beam with a photon energy of 7.9 keV was focused down to a lateral diameter of several hundred nanometers using the two GINIX Kikpatrick-Baez (KB) mirrors. To ensure the lateral confinment of the beam a pinhole with several microns in diameter was inserted into the beam path ca. 9 mm upstream of the sample, as demonstrated in [2].

The sample, baker's yeast cells (*S. cerevisiae*), suspended in an aqueous film on a thin polyimide sample holder (Mitegen, USA), were fixated before the experiment by rapid injection into liquid ethane using a commercial plunge-freezing apparatus (Leica, Germany). After storage in liquid nitrogen a Kapton holder (see Fig. 1) with sample suspension was inserted into a cryogenic nitrogen stream (Oxford Cryosystems, UK) at about 3 mm downstream of the focus.

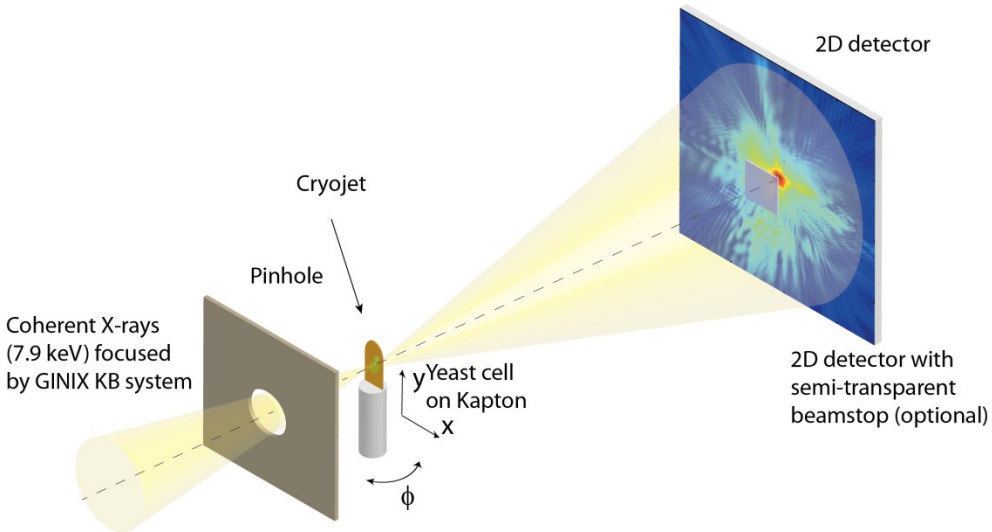

Figure 1: Experimental setup, for more detailed description see main text.

To allow the collection of the high-dynamic range diffraction pattern on the Pilatus detector (Dectris, Switzerland), which was placed about 5.2 m downstream of the focal plane, a semi-transparent beamstop (Si, thickness 300 um) was used as demonstrated in [3] to block the strong central part of the transmitted beam.

For tomographic imaging, the sample holder was mounted on an air-bearing high-precision rotation stage (Micos, Germany) allowing for a rotation about an axis perpendicular to the beam direction (see Fig. 1).

For each 2D projection ptychographic scans of 540 points each with a lateral extension of 11 x 9 μm^2 were collected, with illumination times between 0.15 and 0.2 seconds per scan point. In total, 60 projections in the range from ϕ = -80° to +65° were collected, with 2.5° incremental steps in between. For each of these projections, a 2D ptychographic reconstruction could be obtained successfully using a variant of the ePIE algorithm [4] with an added phase support [5]. A first tomographic reconstruction using standard Filtered Back-Projection has been obtained, with detailed analysis still under way.

References

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