Supporting Information

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SI Text

Numerical Simulations. The slice shown in Fig. S1*A* has been used to compare local phase reconstructions provided by the different phase-stepping methods. As explained in the main text, the slice shown in this figure is a modified version of the Shepp–Logan phantom with real refractive index $n = 1 - \delta$. The δ values in the phantom are similar to the δ values of the soft tissues measured, with hard X rays, in the experiments reported in the main text.

A total of 1,700 interferograms per phase-stepping method have been generated from the phantom, exploiting the fact that the quantity directly measured with the phase-stepping technique, the refraction angle, is proportional to the differential phase of the wavefront at the object plane. Moreover, the phase shift that X rays undergo while passing through the sample is proportional to the line integral along the beam path of the real part of its refractive index (1, 2).

In each pixel, the intensity oscillation recorded during a phase-stepping scan can be written as a sinusoidal function of the grating position x_g and depends also on the sample orientation ω:

$$I(x_g, \omega) = \sin\left[\frac{2\pi}{p_2}\left(x_g + d\int\frac{\partial\delta(x', z')}{\partial x}dz\right)\right], \qquad \textbf{[S1]}$$

where p_2 is the period of the absorption grating G2, d is the intergrating distance, and (x', z') is a coordinate system rotated by ω with respect to the coordinate system (x, z); see Fig. 1 of main text. In Eq. **S1**, the average of the intensity oscillation has been set to zero and its amplitude has been set to one because absorption and scattering effects, which are related, respectively, to these quantities, are neglected in the simulation.

Using the relation of Eq. **S1**, raw interferograms have been generated, from the starting slice, for different pairs x_g and ω to simulate the different phase-stepping methods according to the scheme presented in Fig. 2 of the main text. For example, a standard phase-stepping scan is formed by values $I(x_g, \omega)$ where ω is fixed and x_g assumes values in the interval $[0, p_2[$. In this study, phase-stepping scan were simulated over four steps corresponding to the grating positions $x_g = 0$, $p_2/4$, $p_2/2$, $3p_2/4$.

Phase-stepping scans generated as outlined above, have been processed with the Fourier analysis (3) and refraction angle projections have been retrieved. The number of refraction angle projections obtained in this way was different for the different phase-stepping methods. In particular $1{,}700/4 = 425$ refraction angle projections were obtained with the standard and interlaced methods, $1{,}700/3 = 566$ refraction angle projections were retrieved by simulating sliding window zigzag phase stepping and 1,700 projections were obtained with the sliding window interlaced method.

The refraction angle sinogram obtained with the sliding window interlaced method is shown in Fig. S1*B*, the dashed lines in the sinogram indicate the positions at which the sinograms were truncated. Analogous sinograms have been generated for the standard, interlaced, and sliding window zigzag acquisition schemes. Phase reconstructions of the region of interest of 800 pixels width have been obtained from these sinograms with the filtered back-projection algorithm and an imaginary sign filter (2).

The phase reconstructions are shown in Fig. S1 *C–F* and the results on the histogram analysis is presented in Fig. 3 of the main text. Note that the starting slice was noise free, thus, all noise present in the reconstructed tomograms is generated in the reconstruction process.

1. Weitkamp T et al. (2005) X-ray phase imaging with a grating interferometer. *Opt Express* 13:6296–6304.
2. Pfeiffer F, Kottler C, Bunk O, David C (2007) Hard X-Ray phase tomography with low-brilliance sources. *Phys Rev Lett* 98:108105–1018109.
3. Pfeiffer F. et al. (2008) Hard-X-ray dark-field imaging using a grating interferometer. *Nat Mater* 7:134–137.

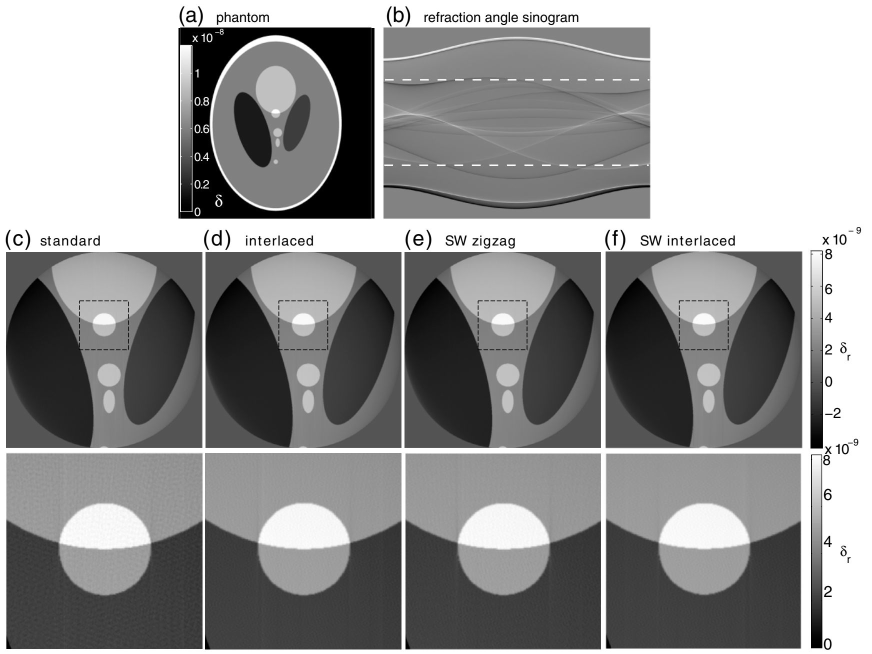

Fig. S1. (*A*) Phase phantom used for the numerical simulations. (*B*) Refraction angle sinogram produced from the phantom by simulating the sliding window interlaced phase-stepping method. Dashed lines indicate the region were the sinogram has been truncated. (*C*)–(*F*) Regions of interest and enlarged views of an image detail (*Bottom*) reconstructed by simulating the different phase-stepping methods.

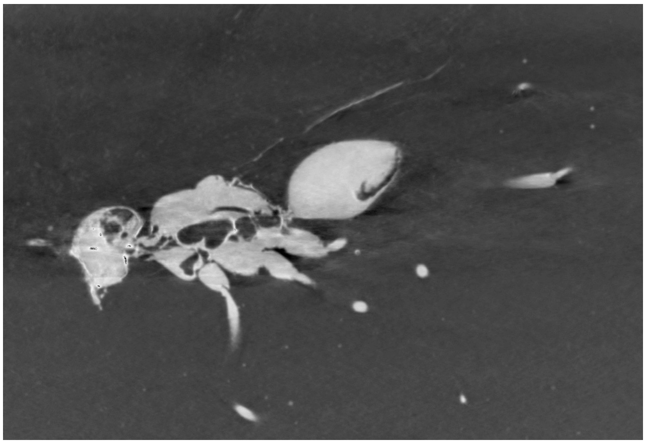

Fig. S2. Phase tomogram of the insect in amber obtained with the sliding window interlaced method. This slice has been obtained from the same dataset that gave the results shown in the images at the bottom of Fig. 6 of the main text.