Quantitative phase imaging and tomography with polychromatic x-rays

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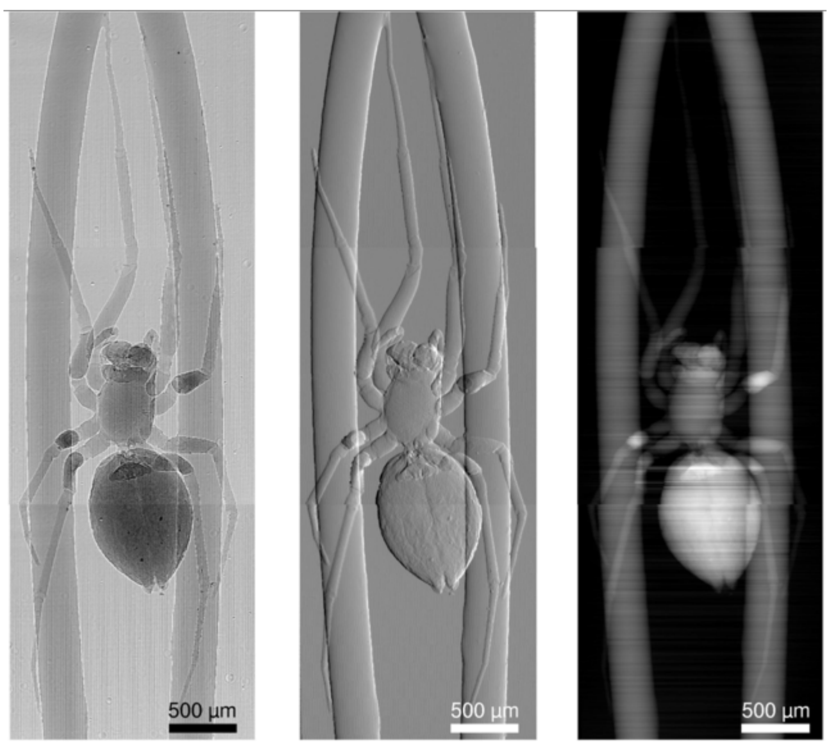
We have developed a two-grating interferometer for hard x-rays that can be used for phase imaging and tomography. The instrument consists of a phase grating acting as a beam splitter and an absorption grating. The recorded signal on the detector is essentially the first derivative of the projected x-ray refractive index in the direction perpendicular to the grating lines. The refractive index can be reconstructed by simple integration. For absorbing samples, the contribution of absorption contrast to the signal can be completely separated from the phase signal by applying a phase-stepping technique during data acquisition. We have used the instrument with a lateral resolution of a few microns and a field of view of 3mm, but it can be scaled up to large fields of view of many centimeters, and correspondingly large pixel sizes. Since the entire setup is quasi-achromatic, the device can be operated with broadband radiation, such as the filtered spectrum of a laboratory x-ay source, or a "pink" synchrotron beam, and is not restricted to monochromatic radiation. We have used synchrotron radiation with a bandwidth of 5 per cent around a mean energy of 17.5keV to quantitatively reconstruct the refractive index distribution in a sample from a tomographic dataset. It was possible to distinguish materials with differences in refractive index of only a few percent. The method is expected to have wide applications in imaging of low absorbing samples such as biological and medical tissue or fibre reinforced polymers.



X-ray micrographs of a spider in absorption contrast (left), interferometric differential phase contrast (middle), and phase contrast (right).