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Phase Sensitive Micro-Tomography With Asymmetric Bragg Reflection

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Using phase information present in a beam after transmission through a sample offers the possibility of reducing the delivered dose while maintaining the visible contrast. Several phase sensivitive imaging techniques have been developed in recent years, among them in-line holography[1], which is now used on a routine base, and analyser based techniques[2] whose feasibility for medical imaging is currently under investigation. Although known for a long time imaging with asymmetric Bragg reflection as magnification optics[3] may be regarded as a further development of analyser based imaging providing two dimensional phase contrast while its two dimensional magnification yields the possibility of using thick fluorescence screens as x-ray to visual photon converter (i.e. commercial CCD-area detectors) thus enhancing detection efficiency at submicrometer resolution. Furthermore, imaging with asymmetric Bragg reflection provides a strong phase contrast and a large field of view on the sample. Recently, our group developed a full theoretical description of the imaging process (including the influences of Bragg reflection and free-space propagation)[4]. This enabled us to verify that a submicrometer resolution limit is achievable, to estimate the minimum detectable phase gradient present in the beam corresponding directly to the minimum detectable density variation in the sample and to understand the influences of beam divergence and dispersion effects. It also provides crucial information about future improvements of the experimental setup. In order to avoid artefacts during tomographic reconstructions phase retrieval algorithms have to be applied to the measured images. Several of these algorithms have been reported in literature differing in the underlying model of contrast formation (i.e. the presence of coherence, absorption or small angle scattering) and thus producing different kinds of quantative information about the sample. Our latest measurements at the ID-19/ESRF beamline will help to identify the most appropriate algorithm in case of magnifying analyser based imaging. Furthermore, we expect to directly measure the maximum achievable resolution limit in experiment for both two dimensional imaging and three dimensional reconstruction.

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Phase contrast imaging and tomography with hard X-rays and cold neutrons

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We report how an interferometic method can produce quantitative x-ray and neutron phase contrast images. The interferometer is based on diffraction gratings fabricated using microlithography techniques. Separate phase and absorption images are recorded simultaneously [1]. By taking data sets under many viewing angles, a tomographic reconstruction of both the real part and the imaginary part of the objects complex refractive index distribution can be obtained.

In the x-ray case, the method can be used to enhance the contrast in medical radiography and it has the potential to reduce the applied radiation dose. As opposed to existing techniques, the method requires only little coherence and can be scaled up to fields of view of many centimeters. Its application is therefore not limited to be used at synchrotron light sources, but it can be used with standard x-ray tube sources [2]. This opens up a wide range of applications in medical imaging and non destructive testing.

In addition, very recent experiments with cold neutron radiation are presented [3]. Again phase contrast images and tomographic data sets were recorded. Our technique opens up the way for combining an imaging approach with information obtained through the quantum mechanical interactions of neutrons with matter.

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