Tomography as a constraint for phase-retrieval

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The main challenge of propagation-based (holographic) x-ray phase-contrast tomography is the phase-retrieval step based on intensity measurements in the detection plane. All common techniques require one or several assumptions about the object or additional measurements, for example at different object-to-detector distances. For tomography, single distance images for different projection angles of the object are necessarily available. Because of the finite size of the object, these projections are not independent of each other.
We will present several combinations of phase-retrieval methods and tomographic reconstruction to enhance the quality of the three dimensional complex refractive index or reduce the need of *a priori* knowledge.

In many cases, one-step phase retrieval techniques are used, based on the Transport of Intensity Equation (TIE) or the Contrast Transfer Function (CTF), to retrieve the phase information of all projections indivually, followed by a filtered backprojection for tomographic reconstruction. For weak objects, the order of these steps can be inverted and the phase-retrieval procedure can be carried out in three dimensions. This enables the usage of three dimensional constraints. In combination with iterative phase retrieval methods, the approach can be easily implemented, is computationally efficient and reduces the need for restrictive prior assumptions.

Based on iterative algebraic reconstruction techniques, tomographic reconstruction and phase-retrieval can be carried out simultaniously, reducing the need of *a priori* knowledge. In particular, no assumptions either on the phase-shifting and absorption properties of the object or on the support are necessary. A first investigation with simulated and noisy data proved the robustness of the algorithm. Subsequently, we have also demonstrated excellent reconstructions for experimental data.

The combined problem can also be adressed by iteratively regularized Newton methods, leading to reconstructions of the same quality. A Kaczmarz-type Newton method incereases the computational- and memory-efficiency dramatically.