Non-Scatter Contributions to the Dark Field Signal in DPCI

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In grating based phase contrast imaging the x-ray intensity in each detector pixel as a function of the grid displacement x is typically modeled as $I(x)=a_0+a_1\cos(x+\phi)$ and the dark field signal is calculated as $-\log(V_o/V_b)$, where the subscripts o and b refer to the object and blank scan, respectively, and $V=a_1/a_0$. The dark field signal is typically attributed to small angle scattering within the object [1]. Wang et al. [2] showed that it is approximately equal to the line integral of the second moment of the scattering angle distribution. Thus, tomographic imaging of scattering is feasible. In this work, we systematically investigate effects, which create additional dark field signals and thus may hamper a quantitative reconstruction of the scattering properties. Specifically, we investigate qualitatively and quantitatively the following effects:

A non-constant phase gradient leads to a local stretching or shortening of the fringe pattern at the location of the analyzer grating. Thus, the fringe pattern does no longer fit the pitch of the analyzer grating, which creates a contribution to the dark field signal.

Effects caused by the fact that the finite sized detector pixel cannot resolve edges in the image are typically called partial volume effects. Similar to the non-constant phase gradient case, imaging an edge of a phase object leads to a local deformation of the fringe pattern which causes again a contribution to the dark field signal.

If the signal in the detector pixel does not exactly follow the model function, higher frequency components are present, which are aliased into lower frequencies. This can lead to a contribution to the dark field signal.

Finally, detector crosstalk mixes the signals of neighboring detector pixels. In conventional x-ray imaging, this leads mainly to a loss of spatial resolution. However, in DPCI imaging, cross-talk can also induce a contribution to the dark field signal.

Simulations of these effects and the evaluation of experiments indicate that in typical situations, the partial volume effect creates the strongest dark field signal.

[1] F. Pfeiffer et al., *Nature Materials*, **7** (2008) 134.

[2] Z. Wang et al., *Proc. Fully3D Meeting 2009, Beijing, China*, (2009) 438.