Comparison of the Contrast Transfer Functions for Differential Phase Contrast with a Split, a Quadrant, and a Center of Mass Detektor

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Electric and magnetic fields in thin specimens can be quantitatively determined using the differential phase contrast (DPC) method in a Scanning Transmission Electron Microscope (STEM). Essentially the method is based on measuring the deflection of the illuminating cone with a segmented detector, typically a split or a quadrant detector. For high spatial resolutions, however, the contrast in the image of a thin specimen has to be described more generally using a contrast transfer function.

Traditionally one uses split or quadrant detectors to obtain DPC. Recently Müller et al. [1] have demonstrated that the expectation value of the transverse momentum of the incident electrons is changed by an amount proportional to the transverse electric field in the specimen. They therefore propose to determine this momentum transfer by measuring the two-dimensional "center of mass" (COM) of the intensity distribution in the detection plane. This has recently been implemented experimentally [2]. To compare the imaging properties of this method with those of the current split and quadrant detector methods, we have calculated the corresponding transfer functions following the procedures outlined by Rose [3] and converted them into phase gradient transfer functions [4]. The results for both - split and quadrant - configurations assuming an ideal lens are shown in figs. 1 a-d.

From the images we see that the center of mass detector exhibits the full circular symmetry in its contrast transfer. The split and the quadrant detector, however, exhibit higher contrast transfer over a large range of spatial frequencies. Unfortunately their contrast transfer is extremely asymmetric.

We are currently investigating the signal-to-noise ratios of the three detectors.

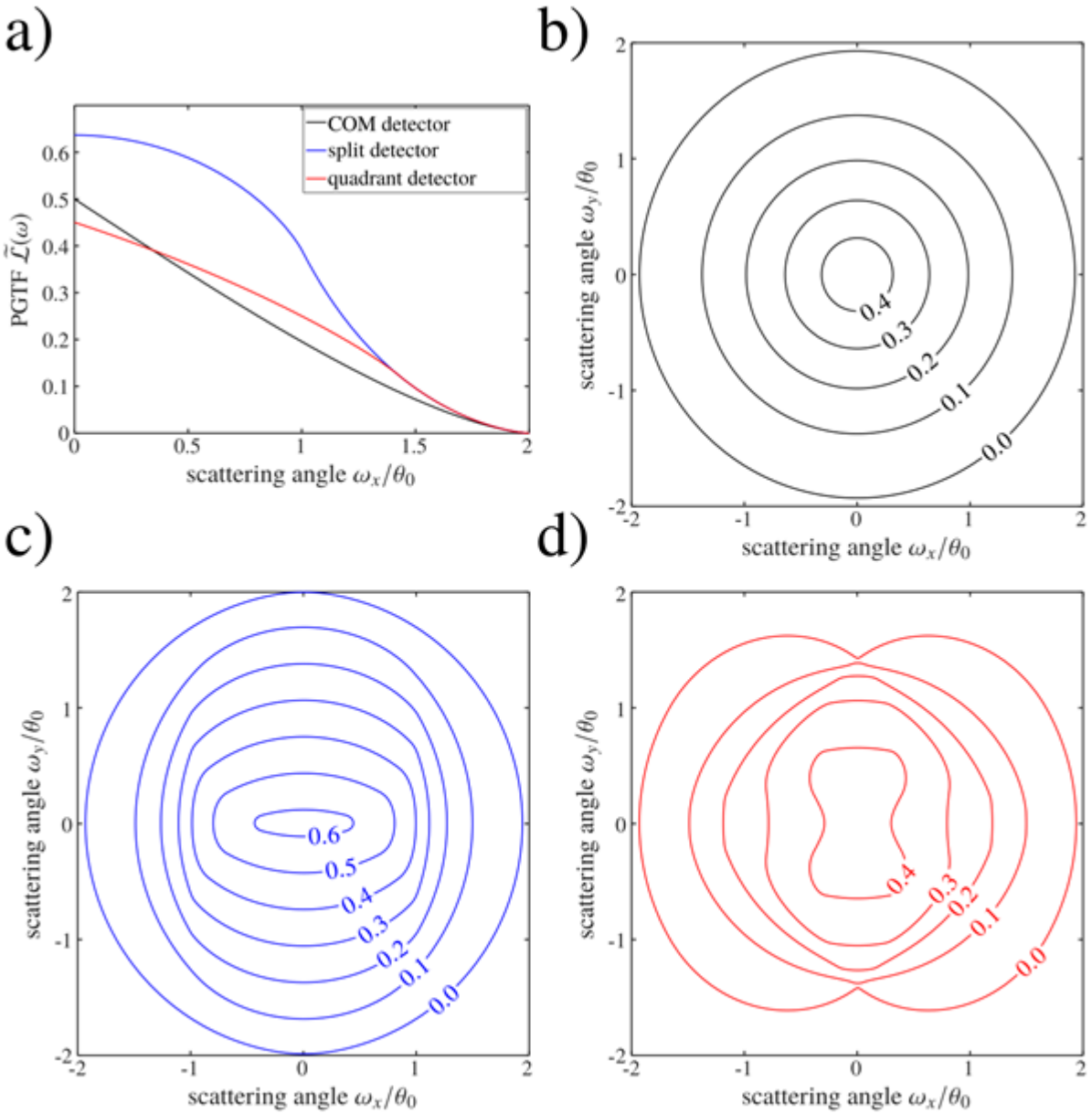

Fig. 1: Profiles (a) and isoline maps (b-d) of the phase gradient transfer function of a center of mass (b), a split (c) and a quadrant detector (d) subtending the full bright-field cone.

[1] K. Müller et al., Nat. Comm. **5** (2014) 5653

[2] F. Schwarzhuber et al., submitted for publication

[3] H. Rose, Ultramicroscopy **2**(1977) 251

[4] J.N. Chapman et al., IEEE Trans. Magn. **26** (1990) 1506