Focal-plane electric field sensing with pupil-plane holograms

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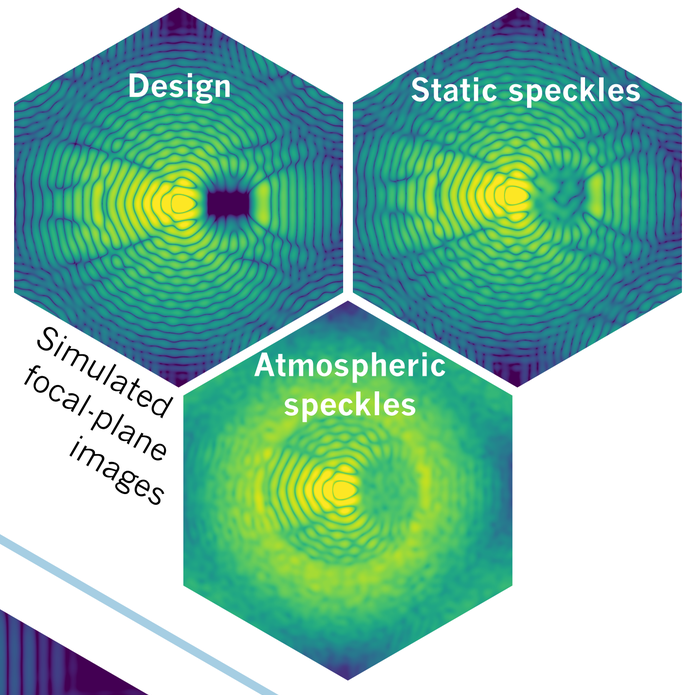
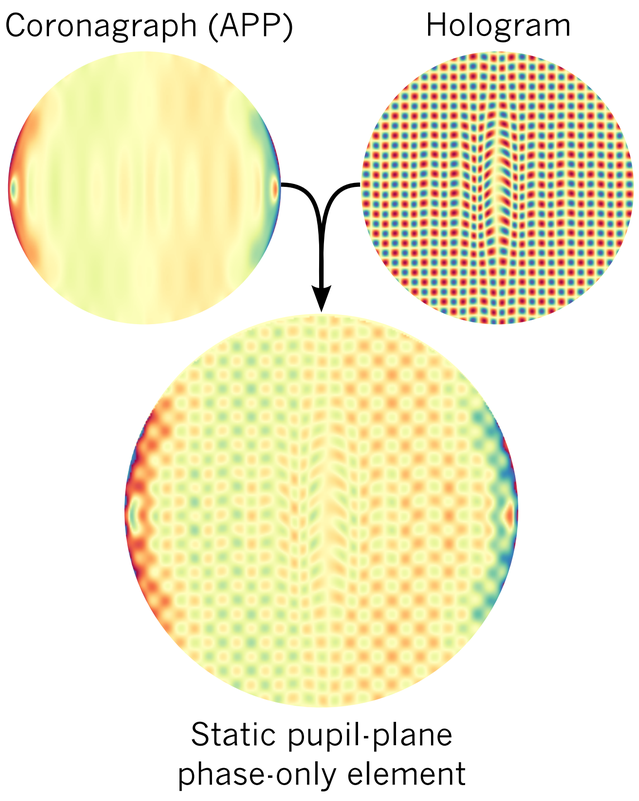
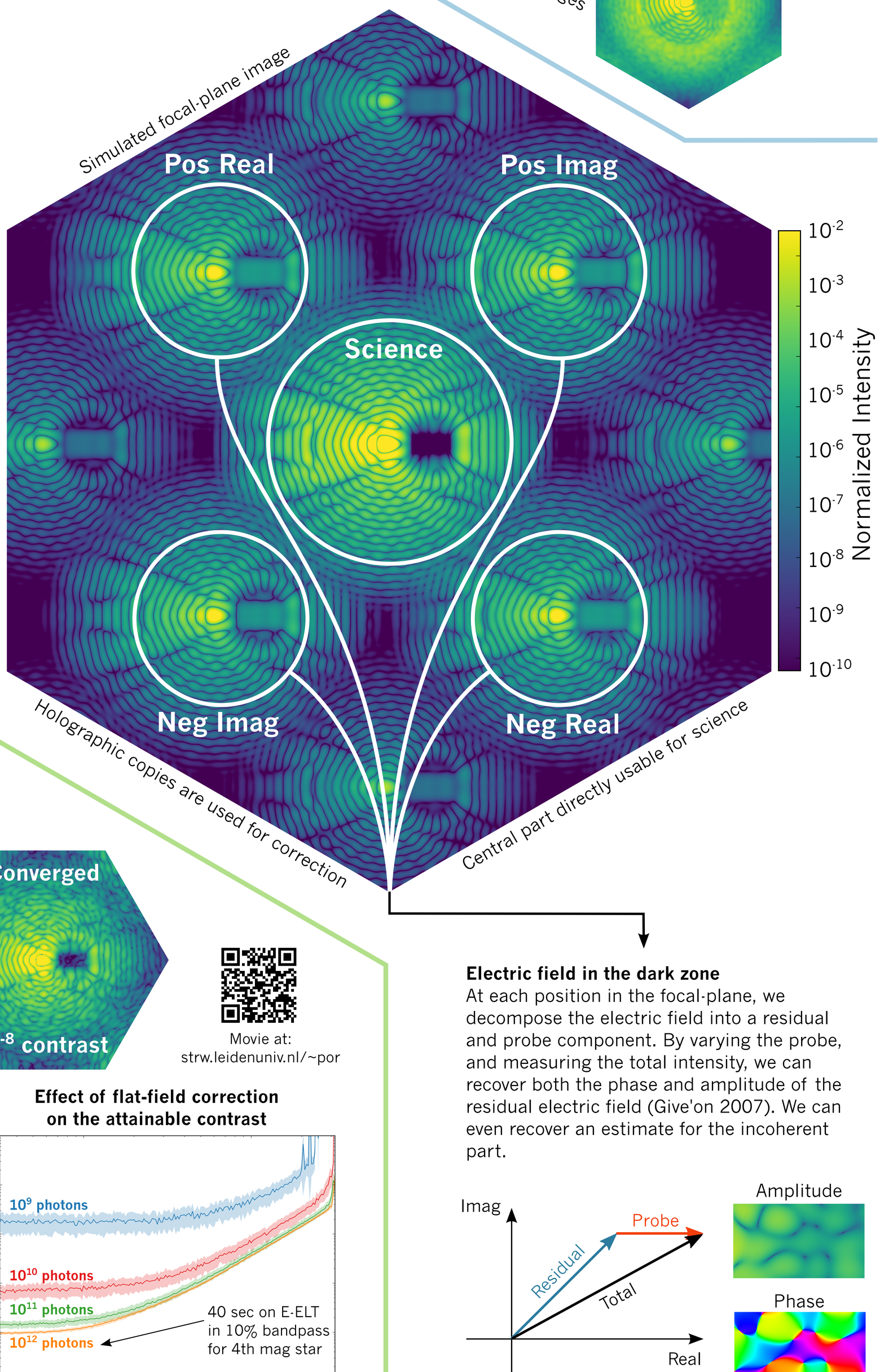
Why high contrast imaging?
Exoplanet detection and characterization are important in astrophysics. Direct imaging is a conceptually simple way of observing exoplanets. Separating the light of planet and star allows us to take spectra of the planet directly, providing clues for formation and chemical composition.

Coronagraphs and aberrations
Coronagraphs create a dark zone next to the star, in which the planet is more easily visible. However, coronagraphs are notoriously sensitive to optical aberrations. Furthermore, on ground-based telescopes we need to deal with the ever-changing atmospheric seeing. Adaptive optics and active speckle suppression allow us to do both.

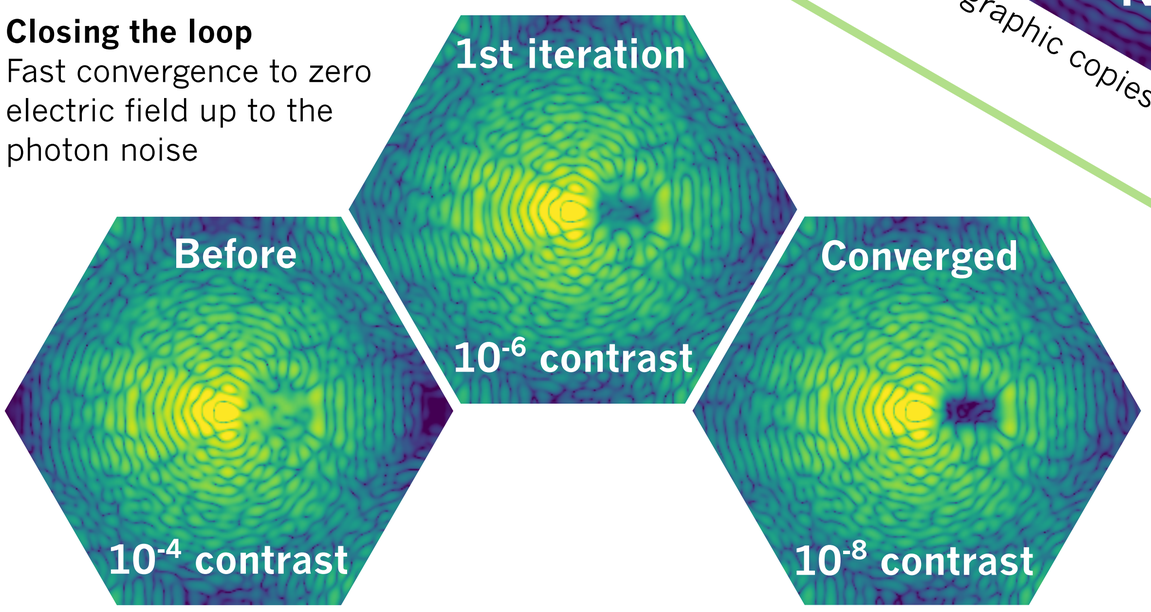


Holographic phase diversity
We use a holographic phase plate to generate copies of the science image, each with a different phase probe in the pupil-plane. These images can then be used to estimate the electric field in the central science PSF. Sensing of aberrations is only performed on the copies, while leaving an unaltered central science image.



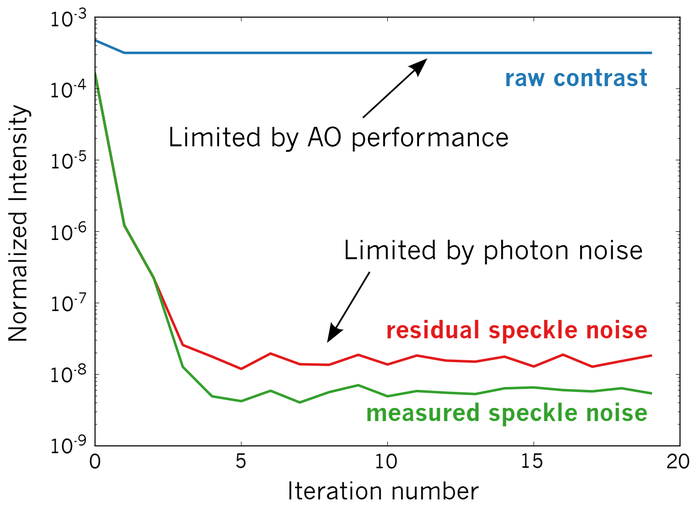


Closing the loop
Fast convergence to zero electric field up to the photon noise



Movie at:
strw.leidenuniv.nl/~por

Fast convergence



Effect of flat-field correction on the attainable contrast

Electric field in the dark zone
At each position in the focal-plane, we decompose the electric field into a residual and probe component. By varying the probe, and measuring the total intensity, we can recover both the phase and amplitude of the residual electric field (Give'on 2007). We can even recover an estimate for the incoherent part.