# BETTER THAN A LENS

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Lenses are designed to interfere all rays constructively at its nominal focus (Fermat's principle). This definition guarantees a maximum concentration of light at the focal point and leads to the *ideal* point-spread function (PSF) or the *ideal* (widefield) optical-transfer function (OTF) in Fourier space respectively (Fig. 1 b, blue solid curve).

The question addressed in our work is whether it is possible to realize an incoherent imaging system that provides an increased optical transfer strength (Fig. 1b, magenta line), compared to the conventional imaging. First of all, this is of fundamental interest, since it would show that it is possible to circumvent Fermat's principle, yielding a system with a "better than ideal" PSF. Secondly this corresponds to an increased signal-to-noise ratio (SNR), which might have far-reaching impact on a large number of applications (e.g. fluorescence microscopy).

We propose and experimentally show a novel and fundamentally new concept, by splitting the pupil of an imaging system into two parts to simultaneously obtain sub-images via each of these sub-pupils (Fig. 1a). Recombining them by weighted averaging in Fourier-space yields an enhancement in (Fourier-) SNR at high spatial frequencies, compared to conventional imaging. The proposed technique only makes use of a single acquisition process and works in the photon-limited regime, hence is well suited for imaging scenarios with a limited number of photons and high numerical aperture.

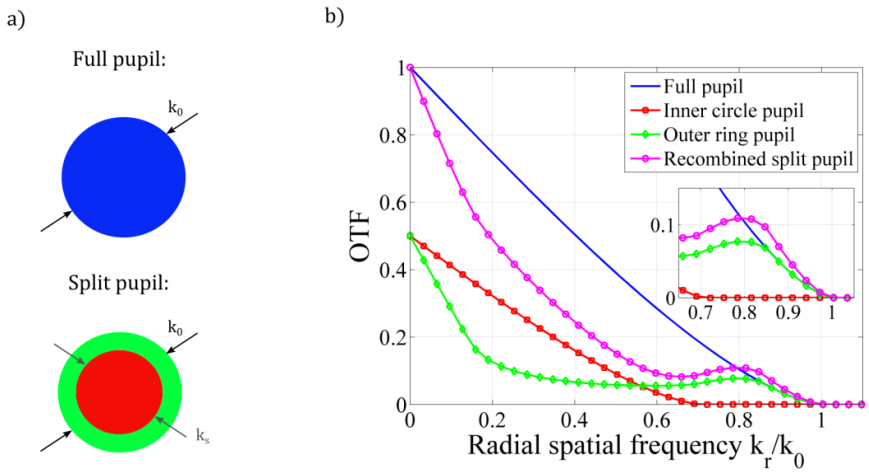


Figure 1: a) Visualization of circular full (blue) and split-pupil; split into an inner circle (red) and an outer ring (green). b) Efficiency-normalized OTF's corresponding to FP-, the two sub-pupils and the noise-normalized recombined result. ($k_r$: radial spatial frequency, $k_0$: system's cut-off frequency, $k_s$: being the split frequency).