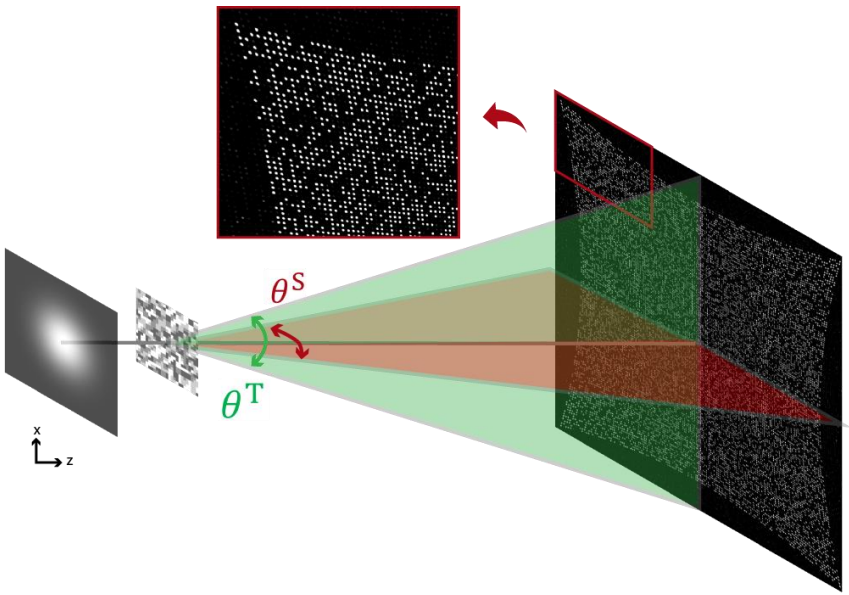
Design of a High-NA Beam Splitter with 24000 Dots Random Pattern

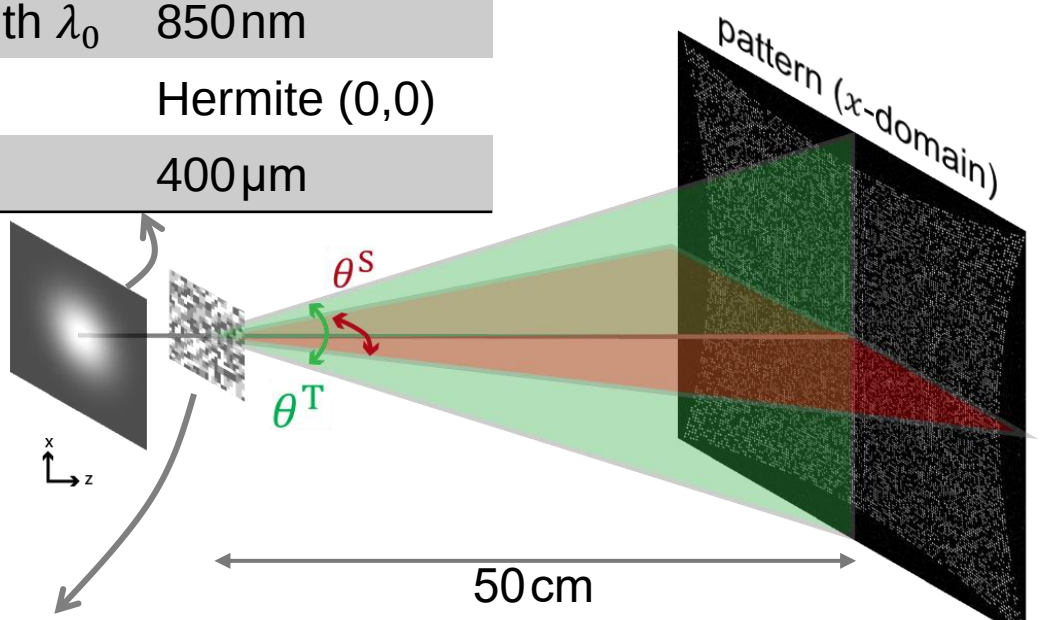
Abstract



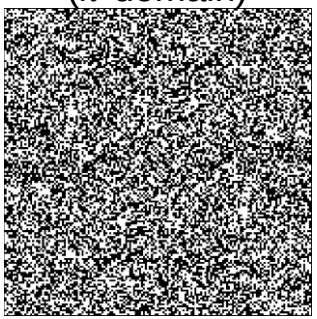
Designing of high NA dot-projection system is of great practical use in the optical market. These dots distributed in a random way. That can be achieved by using a single beam splitter. Generally, the dot-distribution is in an equidistant grid in angle space (κ-domain), which means that the dots propagates along predefined angular directions, while on a distorted grid in the detector plane in spatial domain. This use case shows how to design the phase plate of a single beam splitter to generate 24,000 dots random pattern with high NA.

Design Task

Gaussian beam	
wavelength λ_0	850 nm
mode	Hermite (0,0)
diameter	400 µm



desired pattern (κ-domain)



No. of dots: (155 x 155)

beam splitter	
phase level	2
NA(θ^Tx θ^S)	55° x 55°
working dist.	50 cm

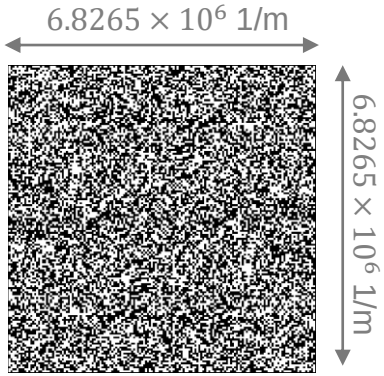
- Desired pattern is a binary random pattern of Hermitian symmetry. Generally, the dots target pattern is given in κ-domain (equidistant-sampled in Cartesian coordinate). It means, each dot is related to one specific propagation angle. Equidistant sampling grid in κ-domain results in a distorted grid in spatial (x-domain) .
- Note that the target pattern is of Hermitian symmetry, beam splitter with 2-level discrete phase is enough to generate this pattern.

Parameters Preparing: Target

- Parameters of target are calculated from NA(θ^{T}x θ^{S})
  - number of sampling points (N_x, N_y) is given
    $N_x = N_y = 155;$
  - window size

n is refractive index of the surrounding medium, here is vacuum.

$$K_x = 2 \cdot \frac{2\pi}{\lambda_0} n \sin\frac{\theta^{\mathrm{T}}}{2} = 2 \cdot \frac{2\pi}{850\times10^{-9}} \cdot 1.0 \cdot \sin\frac{55^\circ}{2}$$
$$= 6.8265 \times 10^6 \text{ 1/m}$$
$$K_y = 2 \cdot \frac{2\pi}{\lambda_0} n \sin\frac{\theta^{\mathrm{S}}}{2} = 6.8265 \times 10^6 \text{ 1/m}$$



(155 x 155)

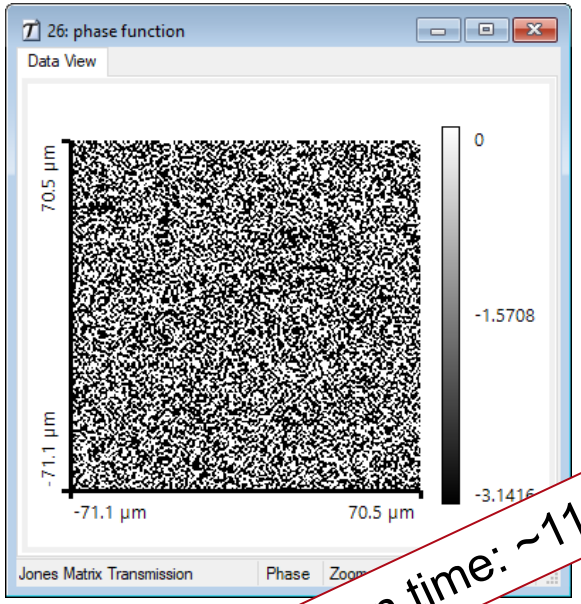
  - sampling distance

$$\delta k_x = \frac{K_x}{N_x - 1} = \frac{6.8265\times10^6}{155-1} = 4.4328 \times 10^4 \text{ 1/m}$$
$$\delta k_y = \frac{K_y}{N_y - 1} = 4.4328 \times 10^4 \text{ 1/m}$$

Param. summary: target pattern	
samp. dist. ($\delta k_x = \delta k_y$)	$4.4328 \times 10^4$1/m
window size ($K_x = K_y$)	$6.8265 \times 10^6$1/m

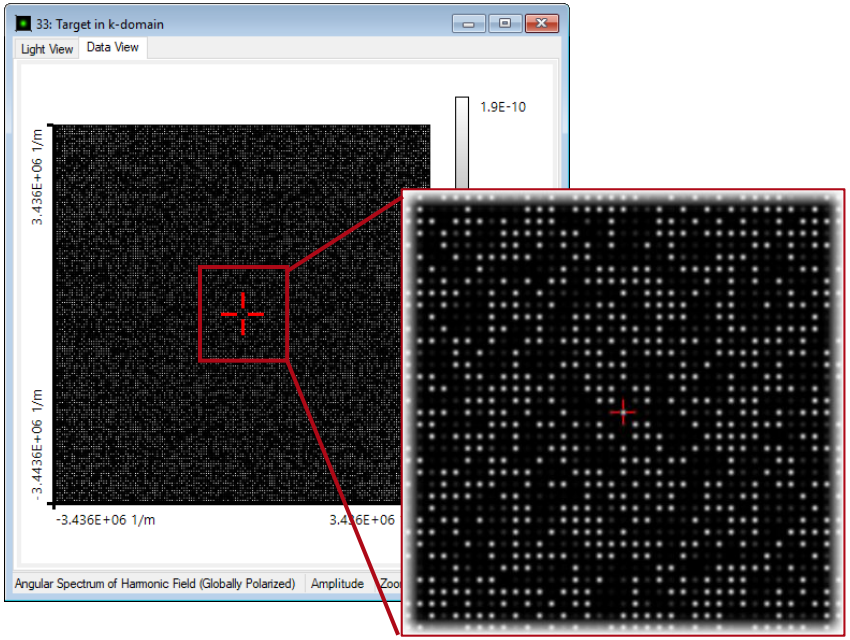
Result: Phase and Target in K-Domain

phase



design time: ~11 s

target in κ-domain

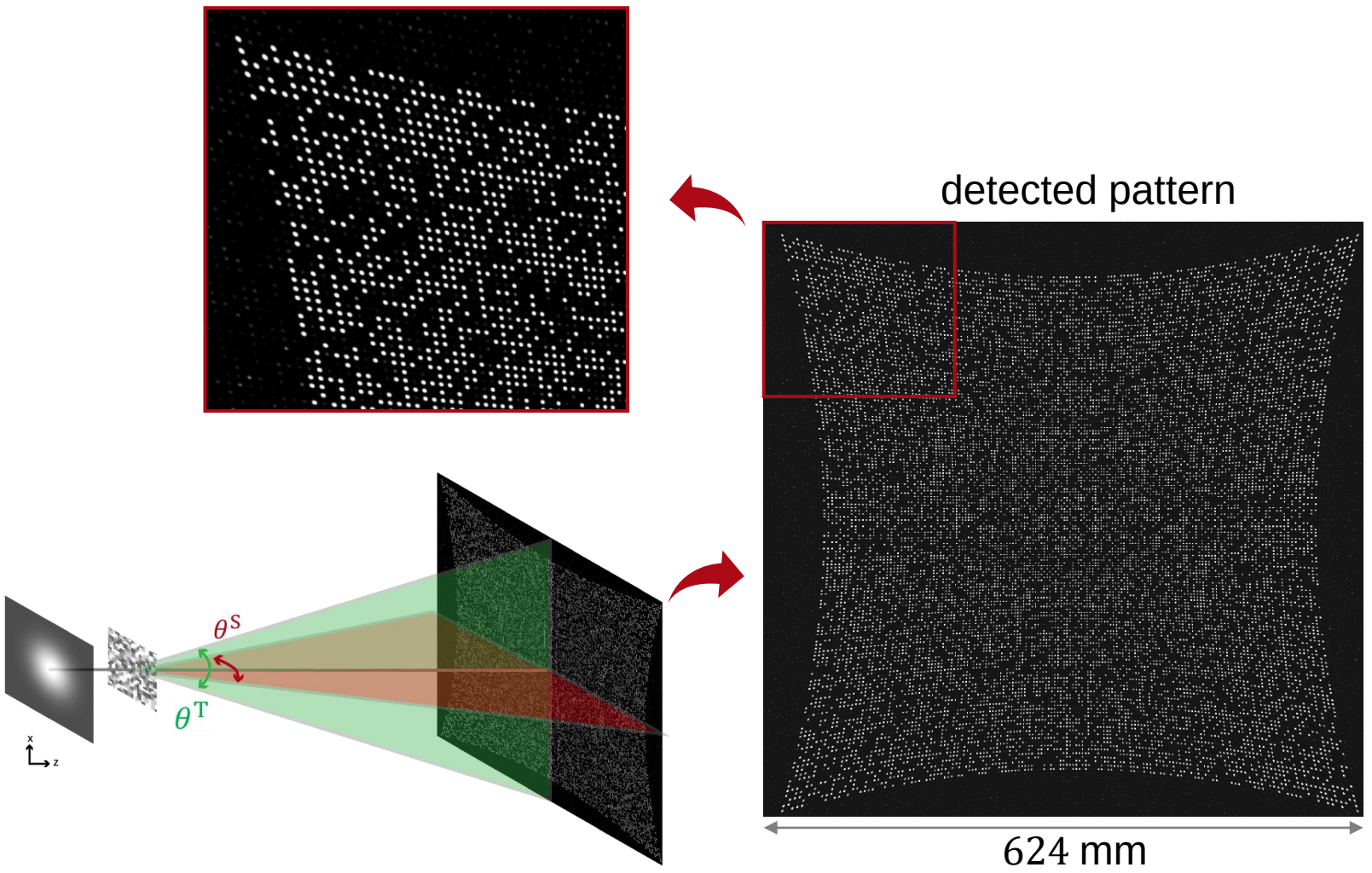


Param. in one period	
samp. dist. ($\delta x = \delta y$)	600 nm
period ($p_x = p_y$)	141 µm

Analysis	
conversion effic.	57.8%
uniformity error	58.1%

Performation can be improved by increasing discrete level of phase, e.g., 8-level phase plate results in conversion efficiency of 68.1% and uniformity error of 27.5%

Result: Detected Pattern



Document Information

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