Multiplexing holograms

2.1 Multiplexed holographic blazed gratings

Blazed gratings have an optimal diffraction efficiency to a single order. The generation of these holograms is depicted in Fig. 2, where we adapt the notation of Dong et al.[7]

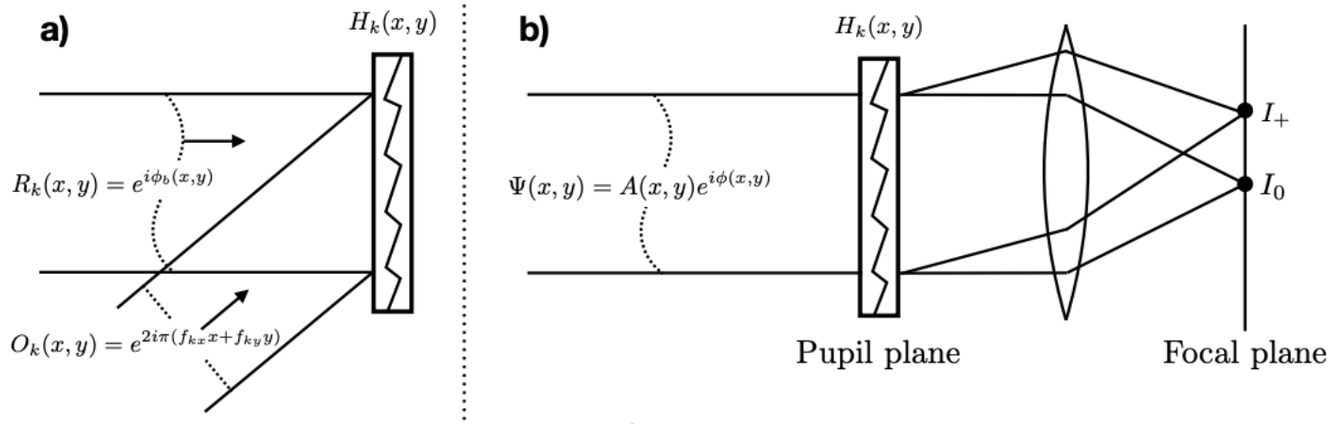

Figure 2: Diagram of holographic blazed gratings. **a)** Visualized generation of the holographic phase pattern. $H_k(x,y)$ is blazed by using only one interference term. **b)** A selected amount of the incoming wavefront is imaged at a separate location in the focal plane. Image adapted from Dong et al. (2012)[7] and Wilby et al. (2016).[8]

We generate an interferogram between a reference wavefront $R_k(x,y)$ with a biased phase $\phi_b(x,y)$ and a object wavefront $O_k(x,y)$. The reference wavefront is given by

$$R_k(x,y) = e^{i\phi_b(x,y)} \tag{1}$$

and the object wavefront by

$$O_k(x,y) = e^{2i\pi(f_{kx}x+f_{ky}y)}, \tag{2}$$

where f_{kx} and f_{ky} are the spatial frequencies the hologram is placed in the focal plane, $f_{kx} = x'_k/f\lambda$. Here the focal plane coordinates are given by (x'_k, y'_k). HAM does not require a biased reference wavefront other than a piston term ($\phi_b(x,y) = c_k$) that is used to phase scramble interferometric PSFs. The interferogram $H_k(x,y)$ between the two waves is then given by

$$H_k(x,y) = |O_k(x,y) + R_k(x,y)|^2 \tag{3}$$

$$H_k(x,y) = |O_k|^2 + |R_k|^2 + O_k^* R_k + O_k R_k^* \tag{4}$$

$$H_k(x,y) = 2 + O_k^* R_k + O_k R_k^*, \tag{5}$$

where * stands for the complex conjugate operator. The interferogram now generates two PSF copies, the ± 1 orders of the grating. Having only one of the two copies is preferred for HAM, as having two would increase the necessary detector space by a factor of two. We therefore blaze the grating by selecting one interference term,

$$H_k(x,y) = O_k R_k^*, \tag{6}$$

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Multiplexing holograms -> spectral information

$$\phi_h(x,y) = \frac{1}{\pi}\arg\left[\sum_k^N s_k H_k(x,y)\right]. \tag{9}$$

An example of a multiplexed holographic grating is shown in Fig. 3.

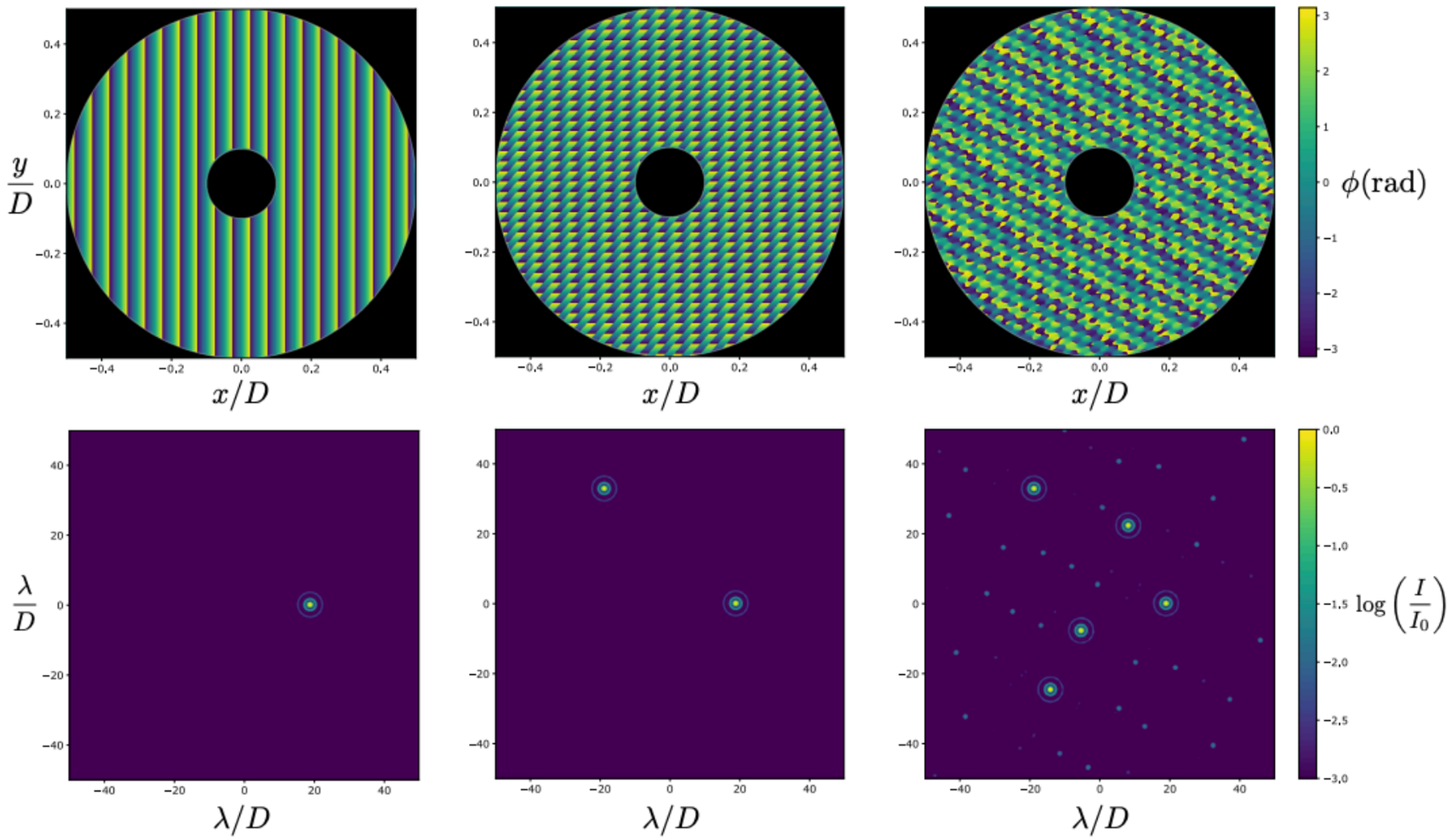
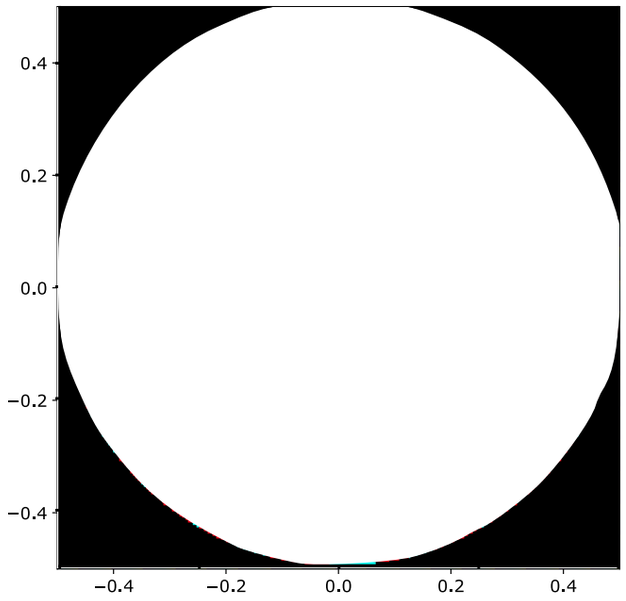


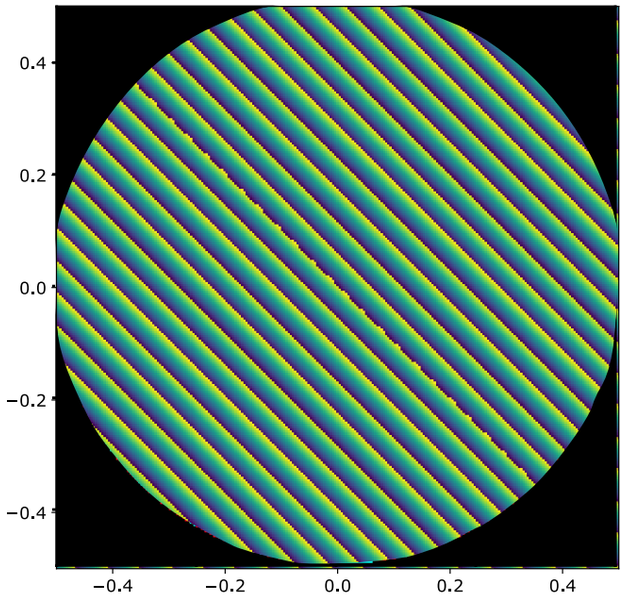
Figure 3: Holographic multiplexing of an aperture. The light is multiplexed in one, two and five holograms from left to right respectively.

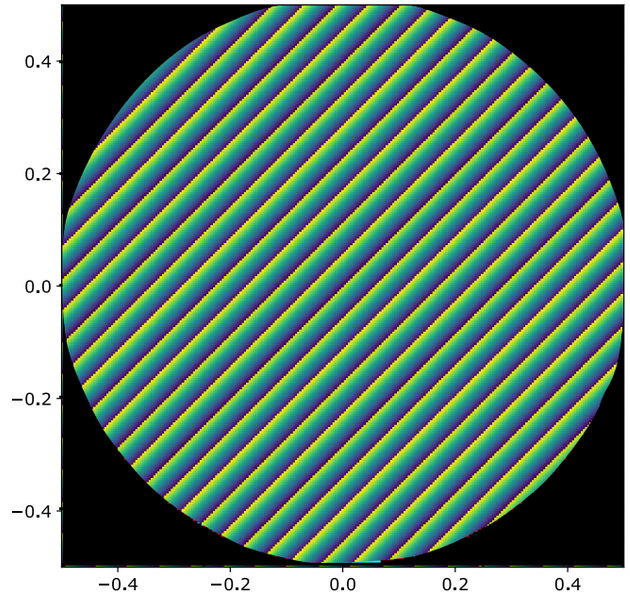
No grating ->Center

Grating period sets location

$$arg(O_k)$$



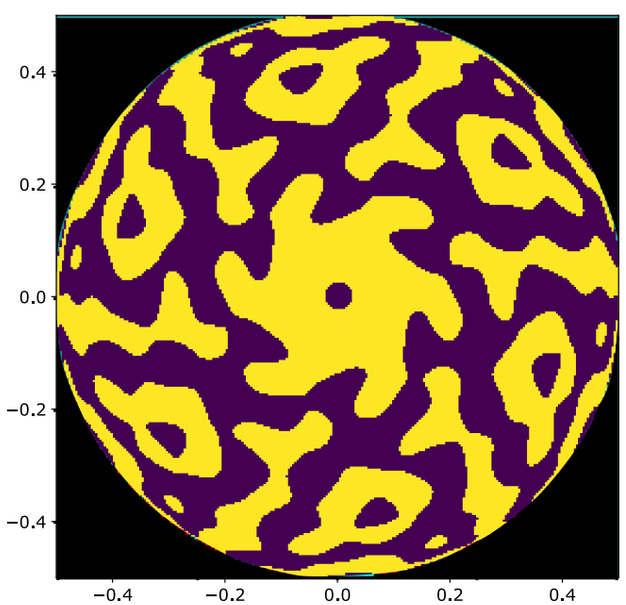


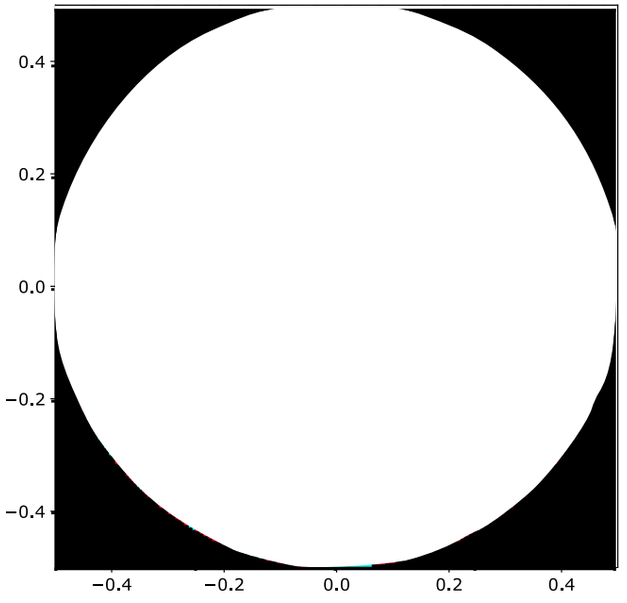


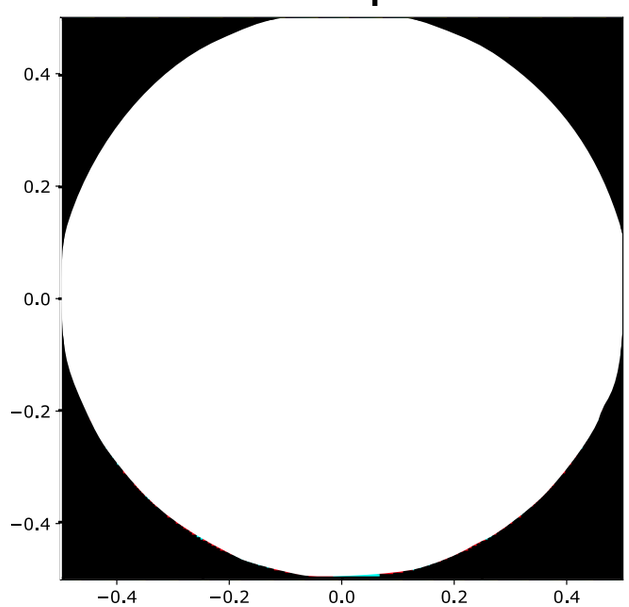
Equation 6 and 9

$$H_k = \quad * \quad + \quad * \quad + \quad *$$

$$arg(R_k^*)$$



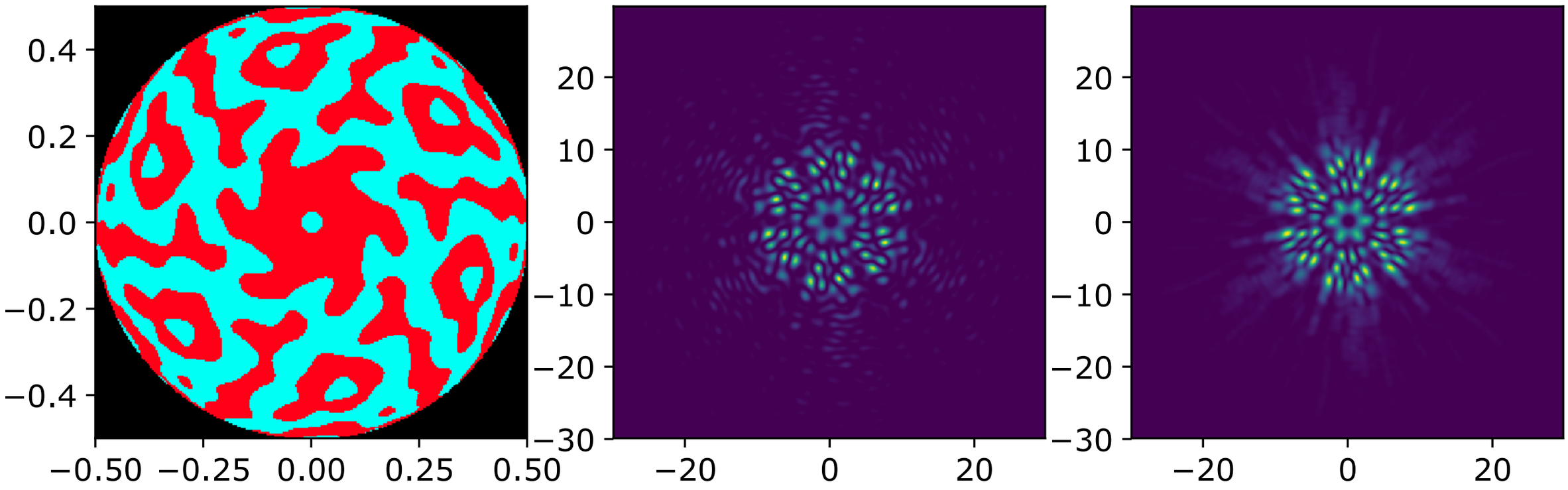


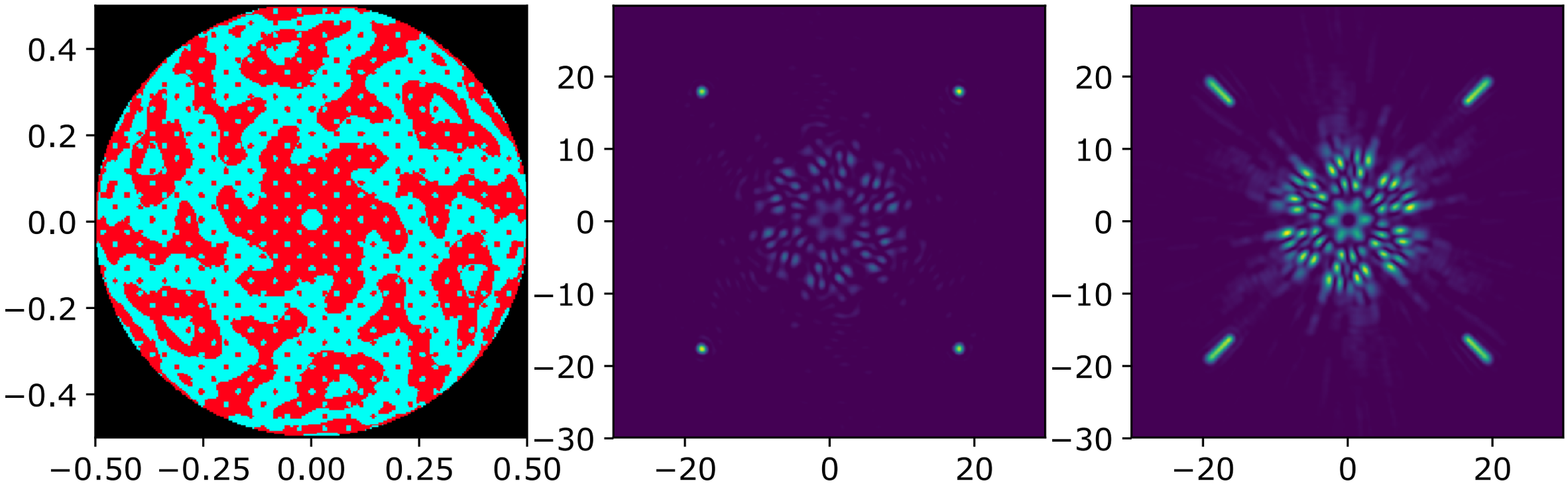


Generates Toliman PSF

No bias -> perfect PSF

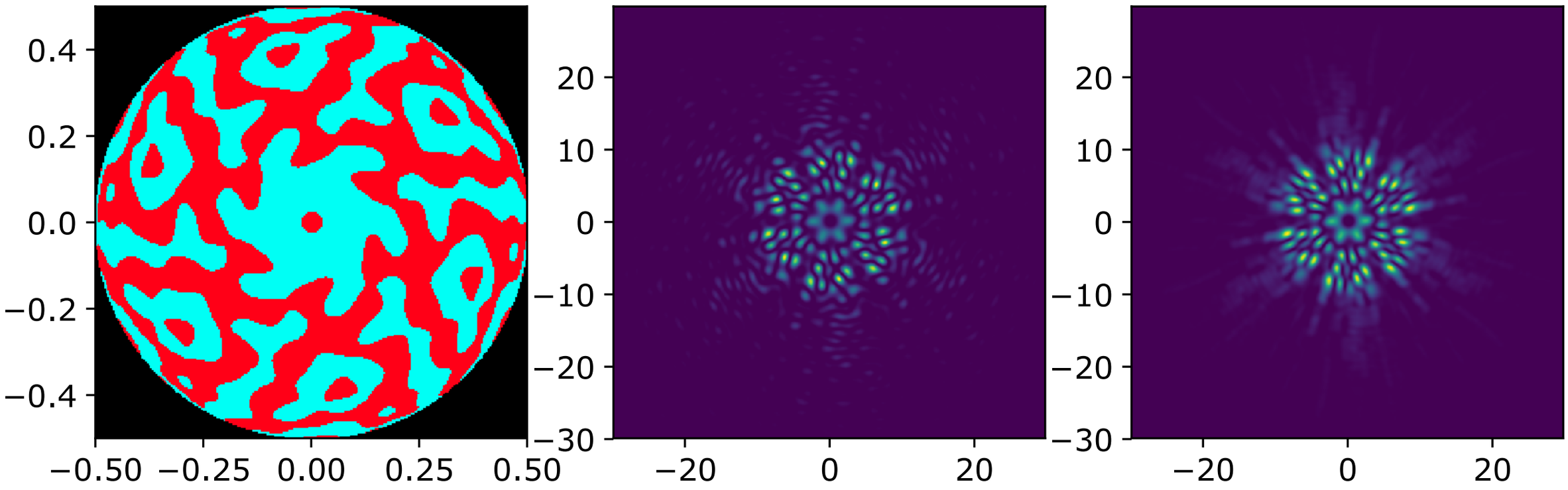
0-pi grating solution

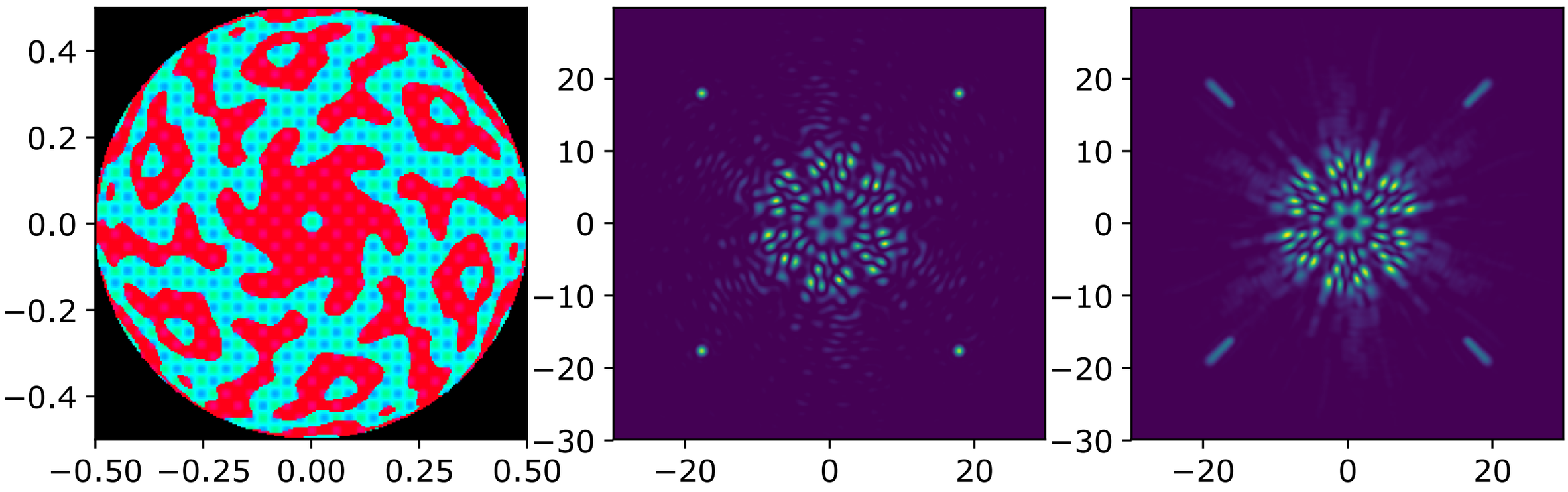




(hologram amplitudes arbitrary)

Continuous grating solution





(hologram amplitudes arbitrary)