

# Development of next generation Vortex Phase Masks

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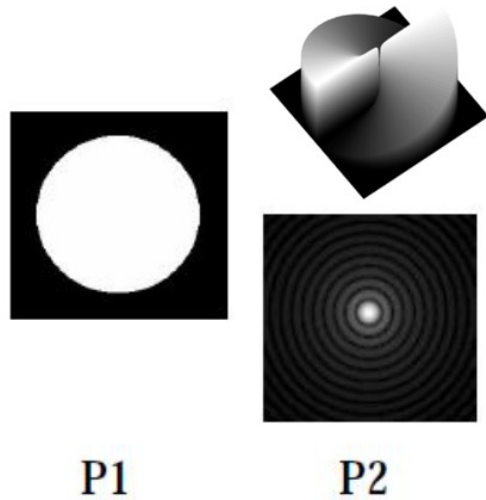
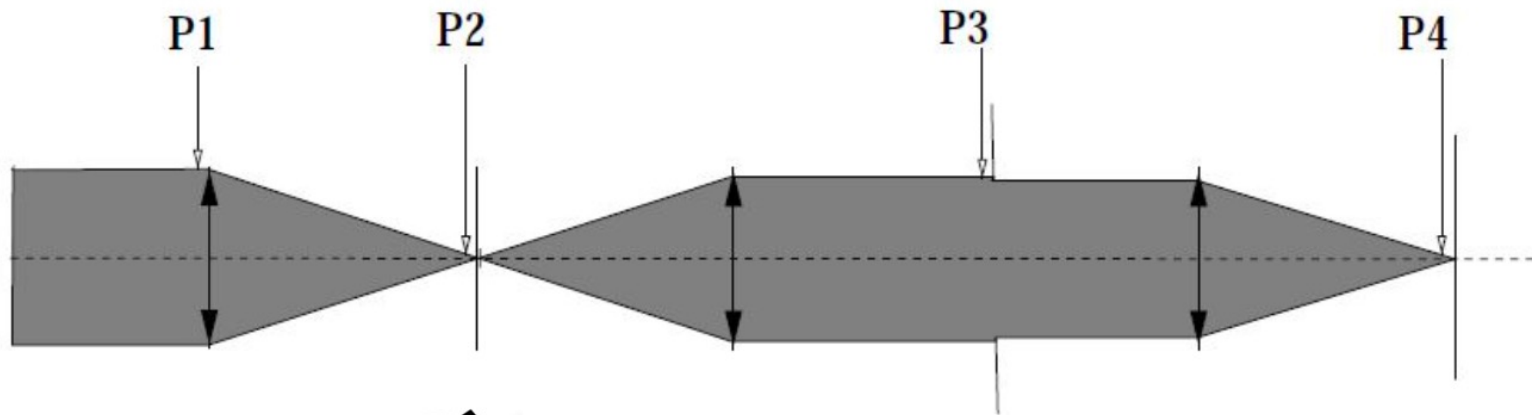
# Direct Imaging of Exoplanets



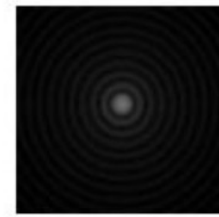
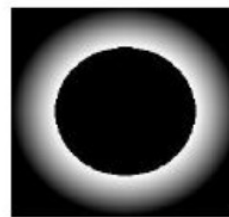
# Direct Imaging of Exoplanets



# Vortex Coronagraphs



Nulling  
coronagraph

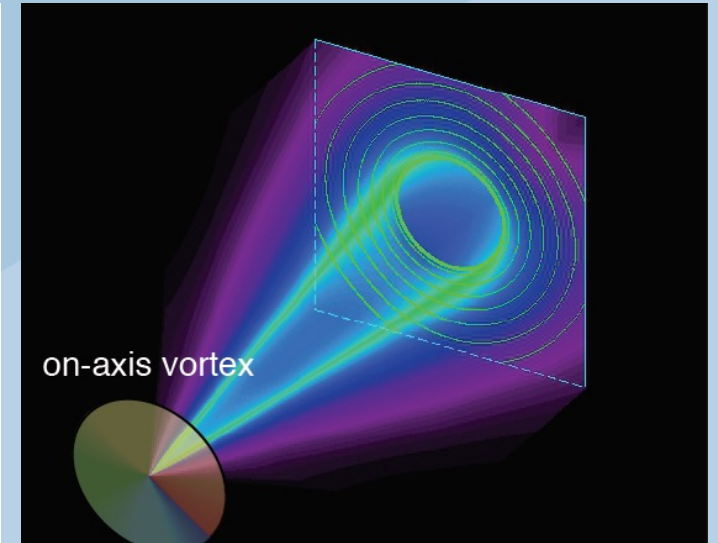


P1

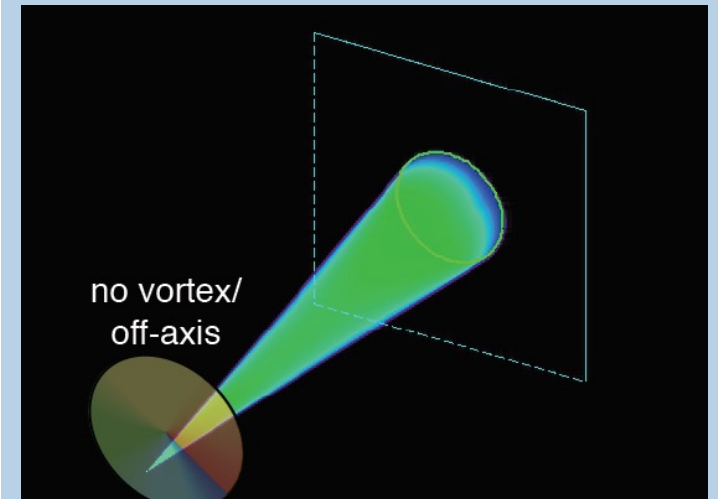
P2

P3

P4

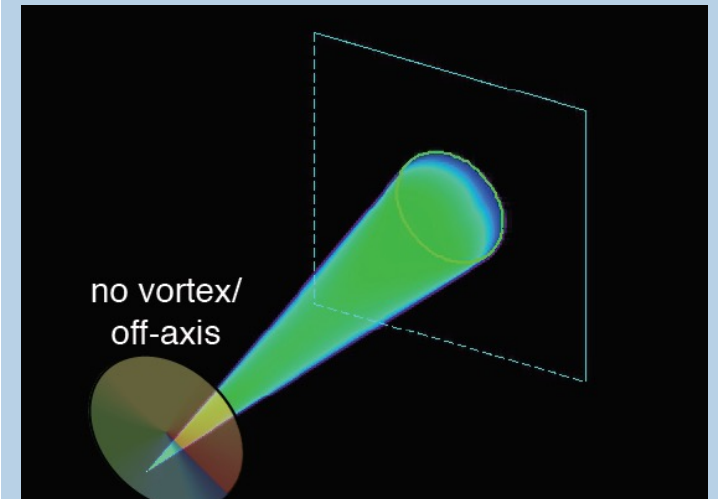
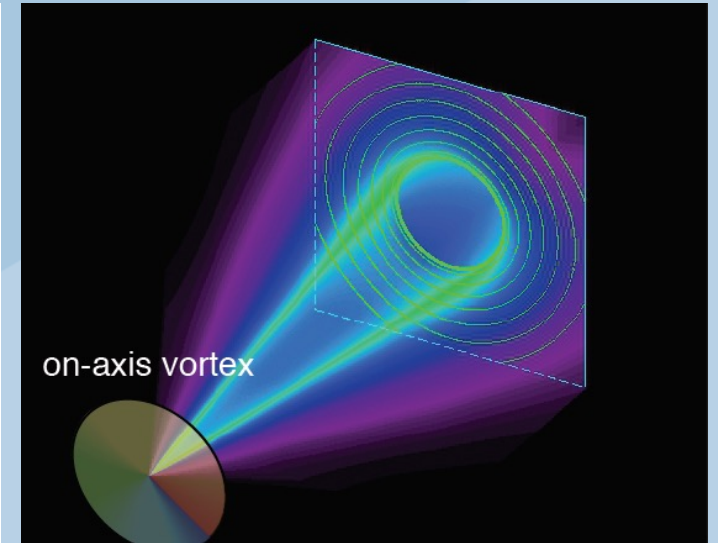
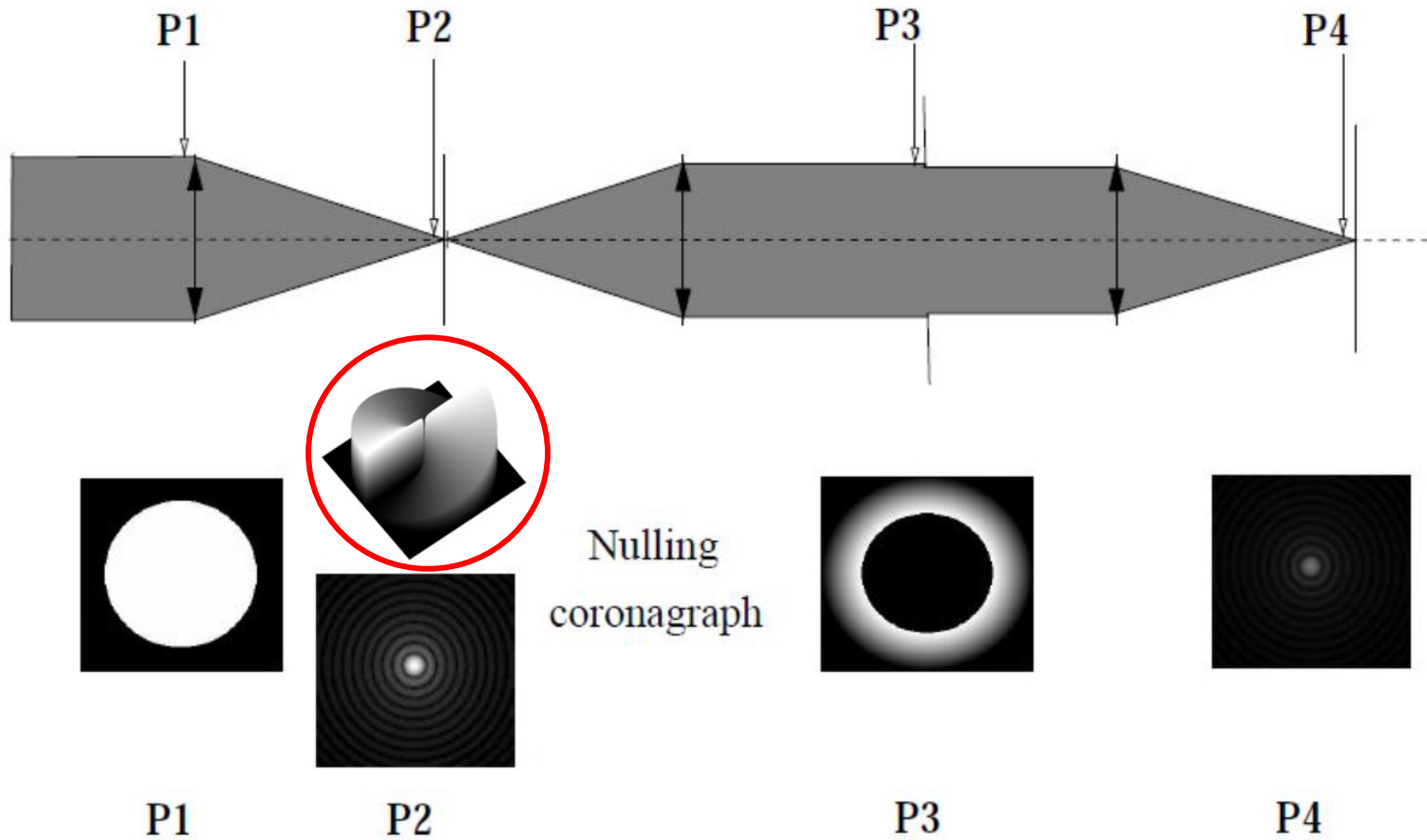


on-axis vortex

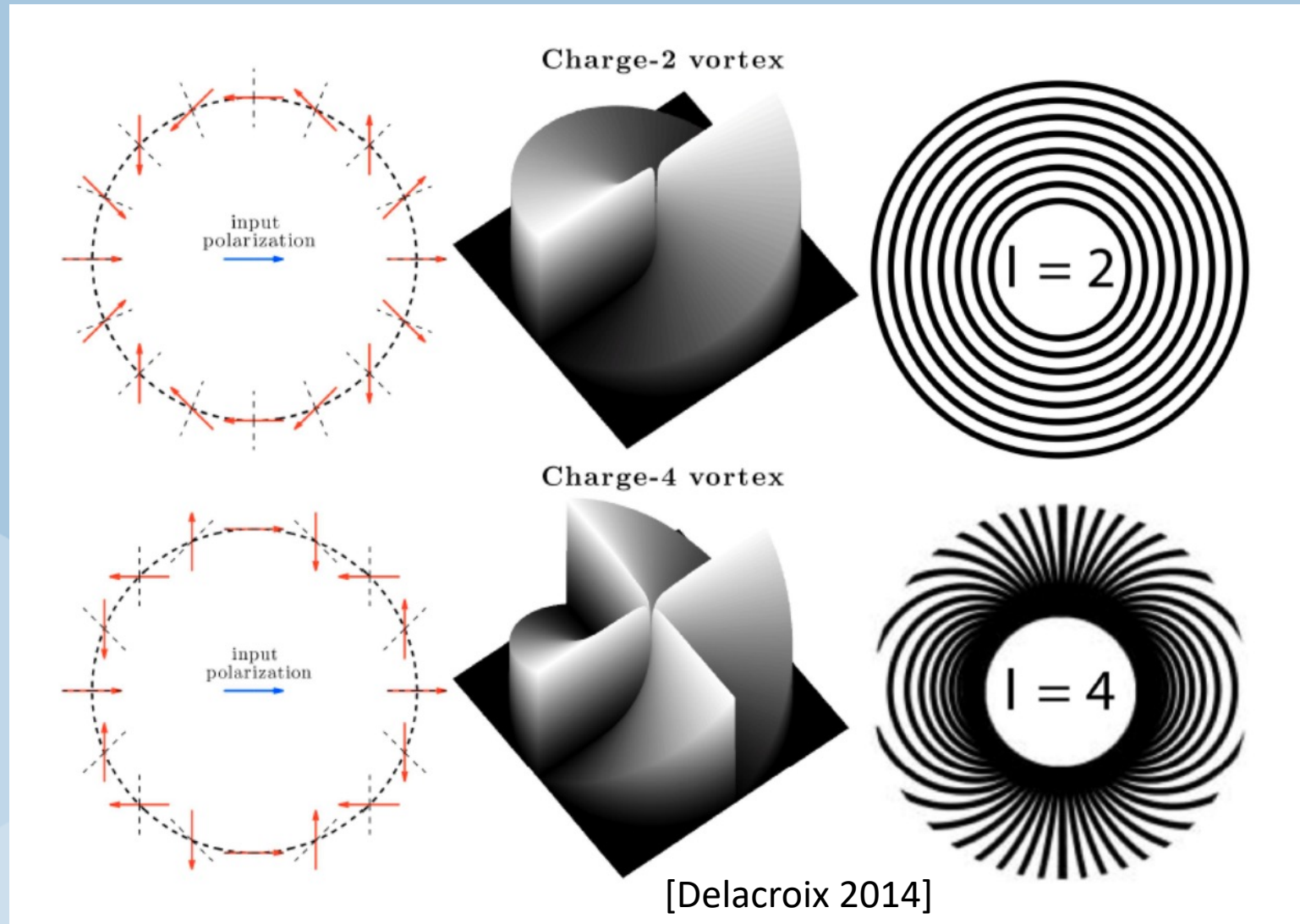


no vortex/  
off-axis

# Vortex Coronagraphs



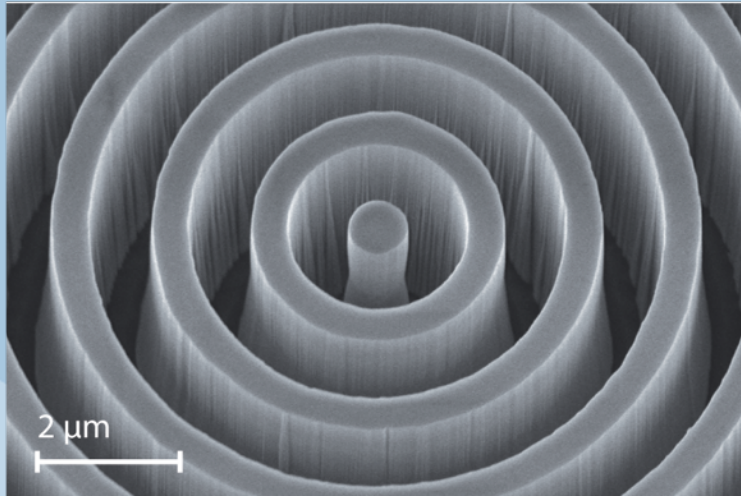
# Subwavelength Grating Vortex Coronagraph (SGVC)



In practice...?

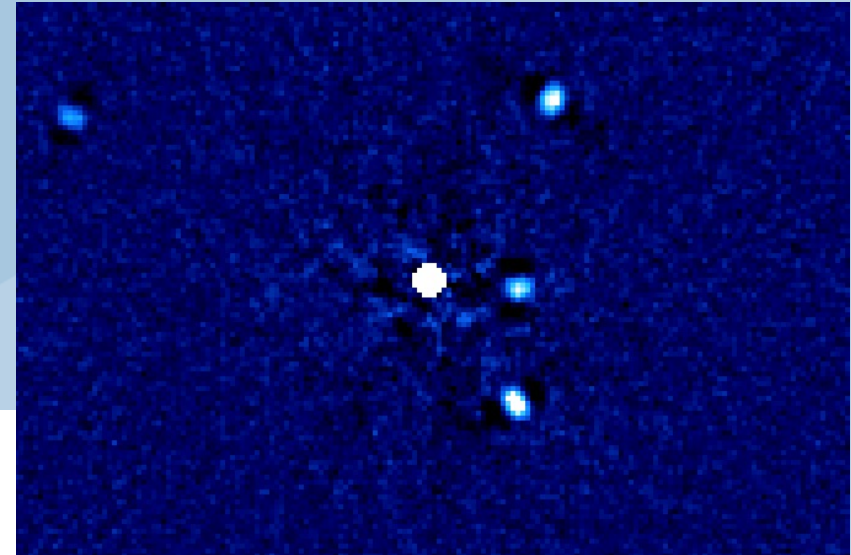


# Annular Groove Phase Mask (AGPM)



Manufacturing in  
Uppsala

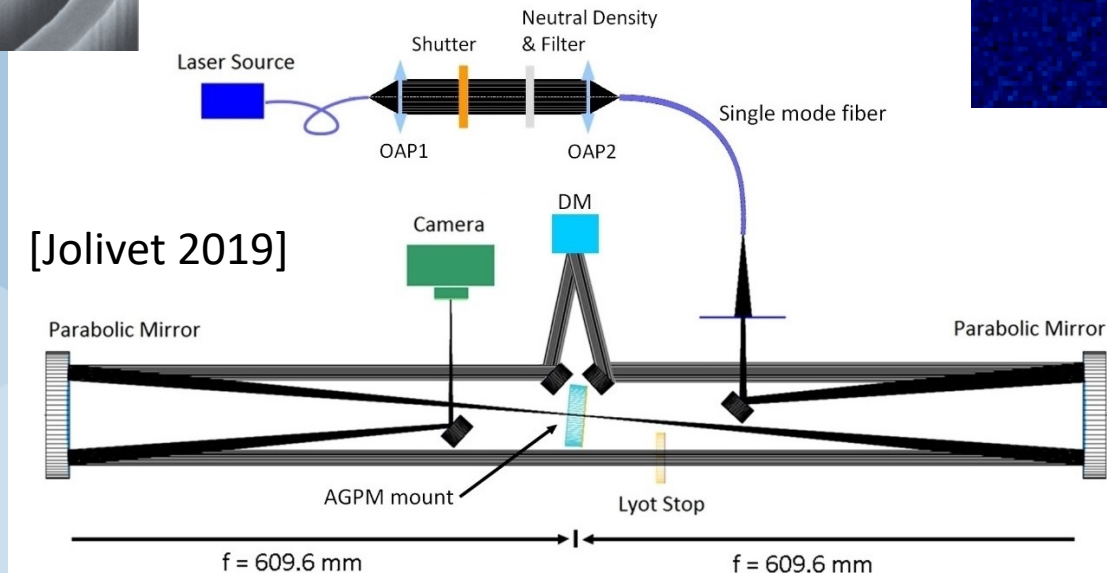
[Delacroix 2013]



[Defrère 2014]

Results from LMIRcam

What's next?

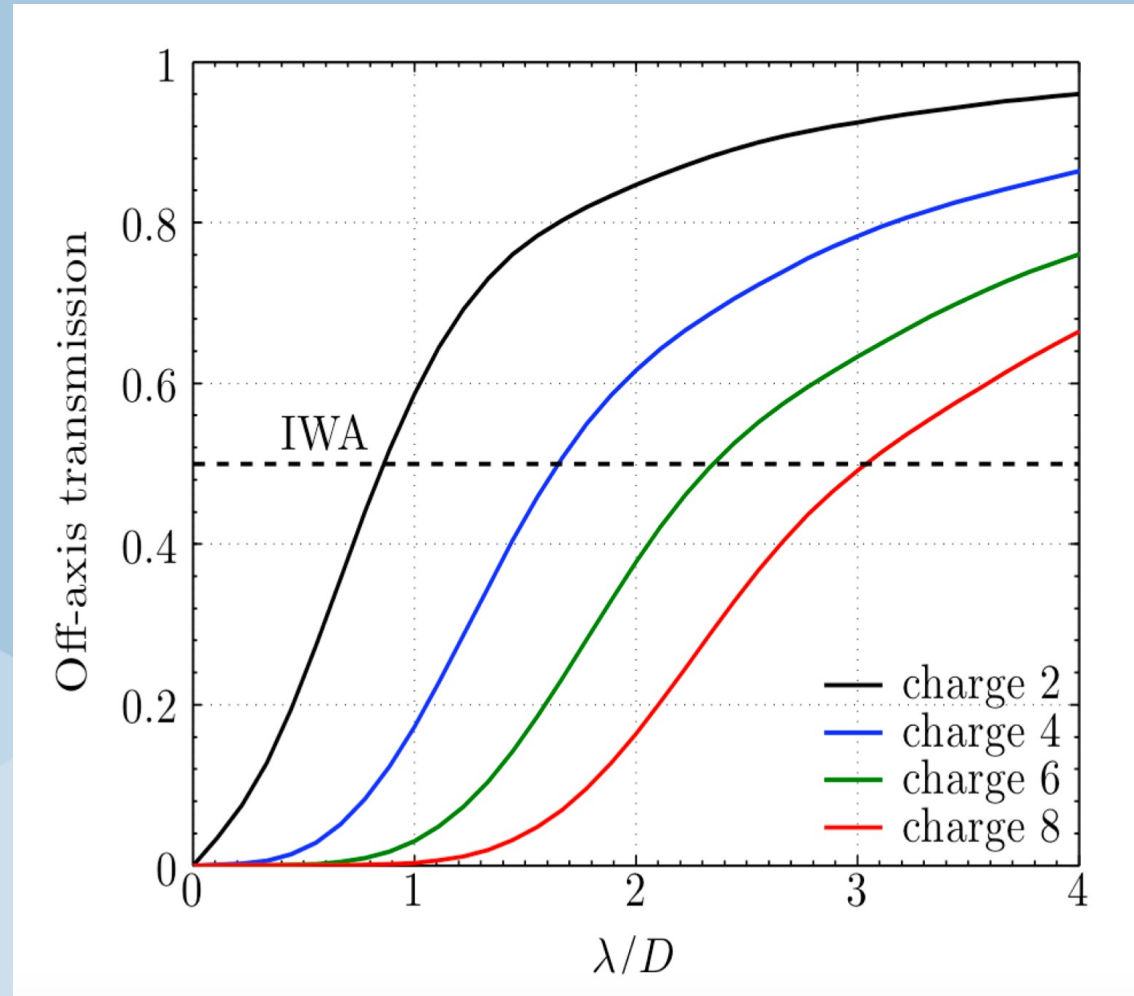


[Jolivet 2019]

Testing on VODCA  
test bench

# The need for higher topological charge

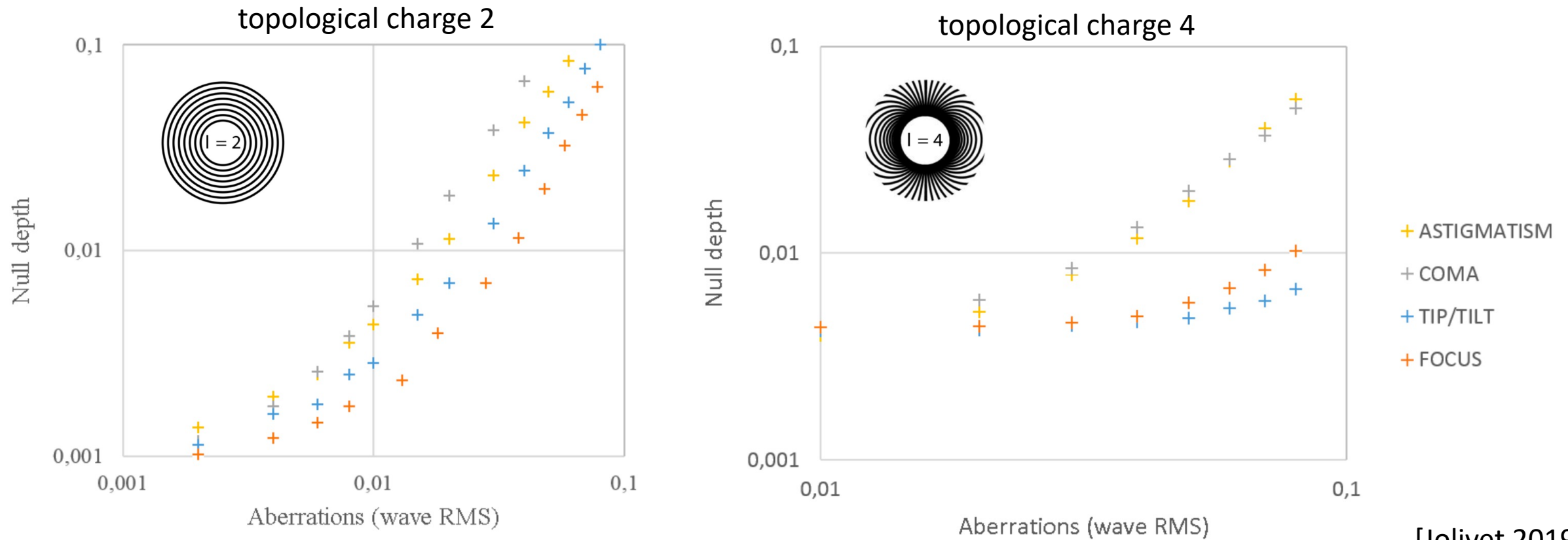
- sensitivity of future telescopes to partly resolved stars





# The need for higher topological charge

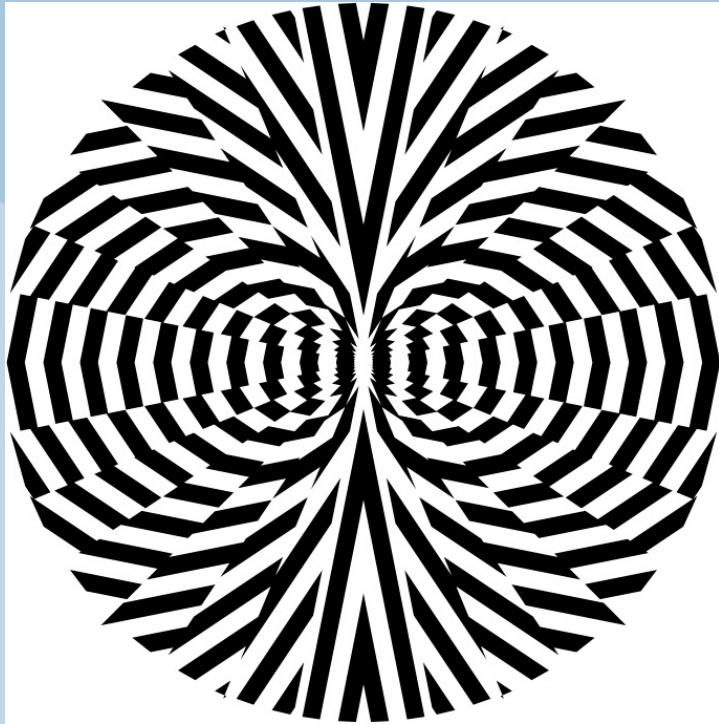
- sensitivity to low order aberrations



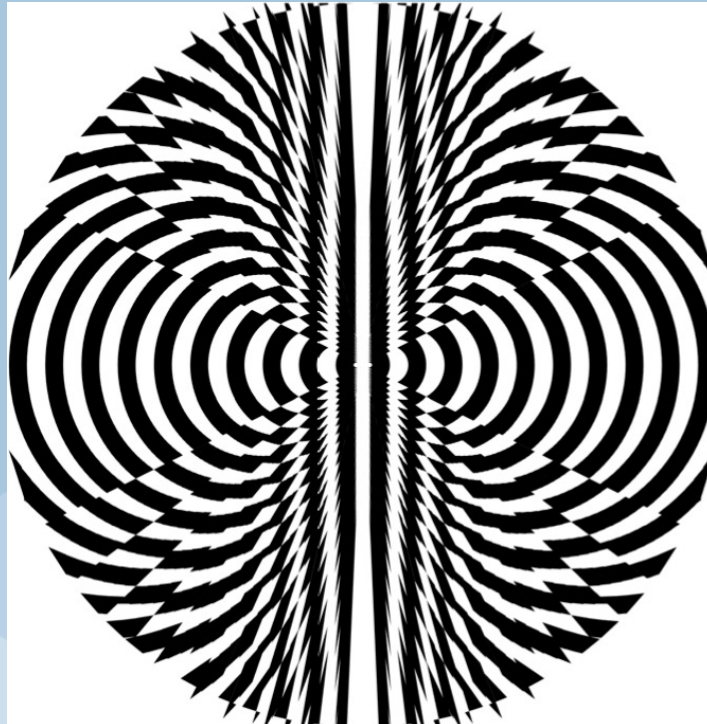
[Jolivet 2019]

# Segmented designs for higher topological charge

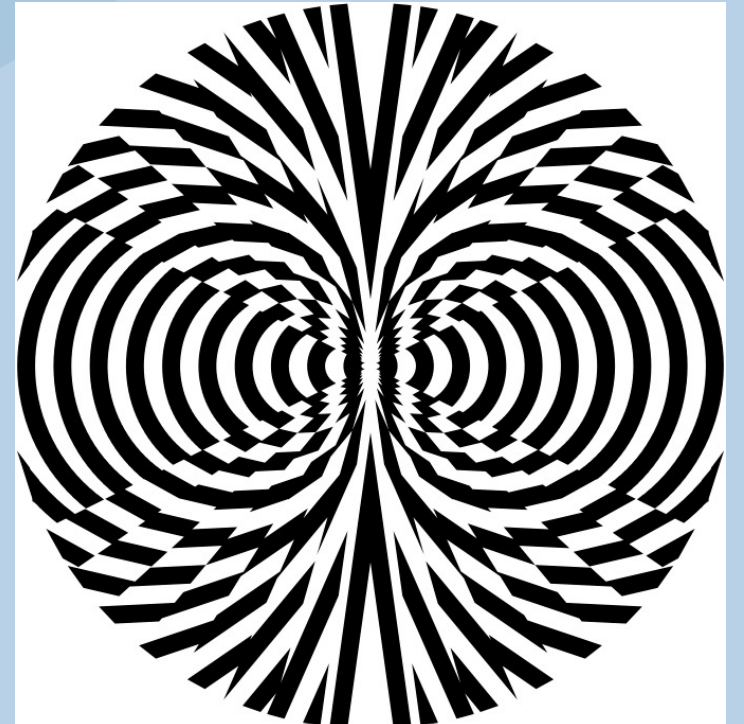
- 3 proposed designs:  
lines



curves

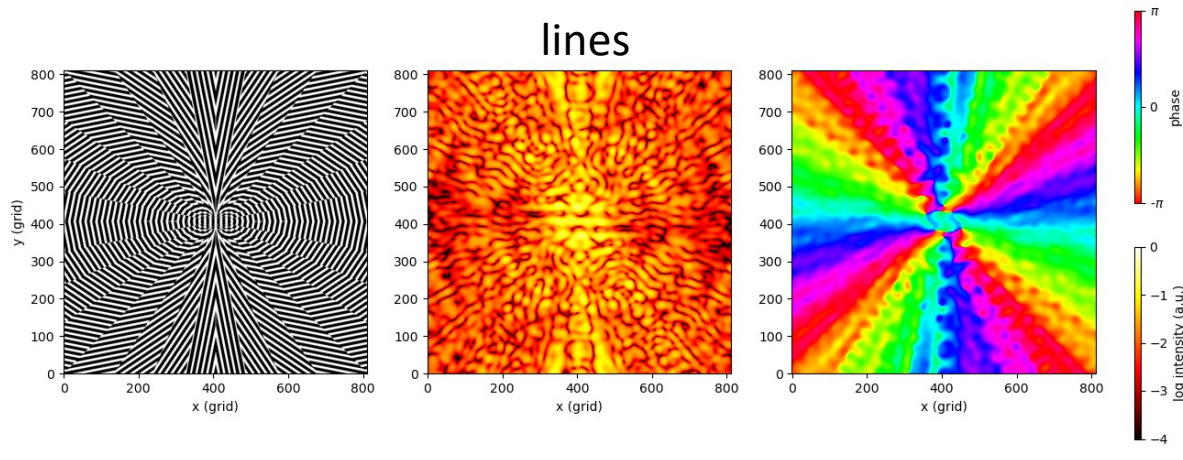


hybrid

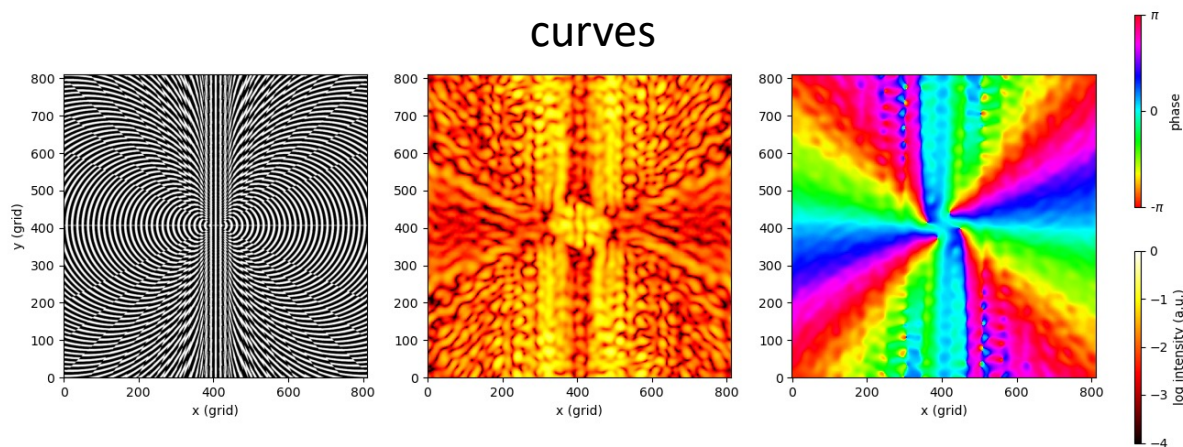


# Segmented designs for higher topological charge

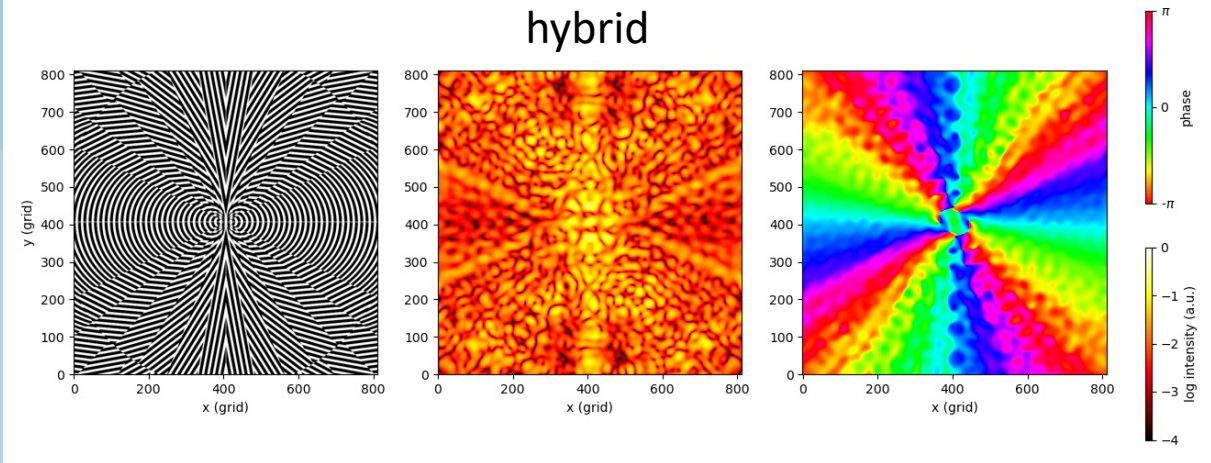
lines



curves



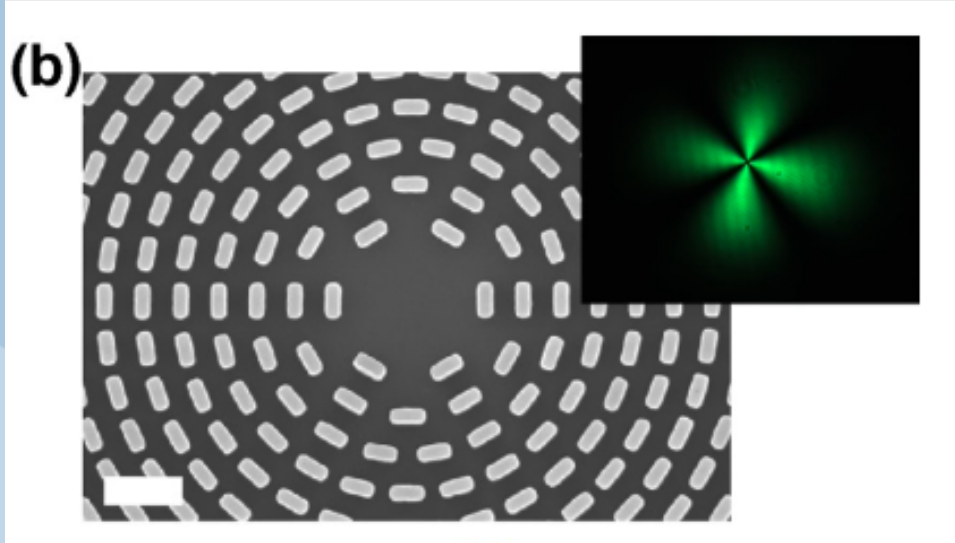
hybrid



But how to avoid transition regions?

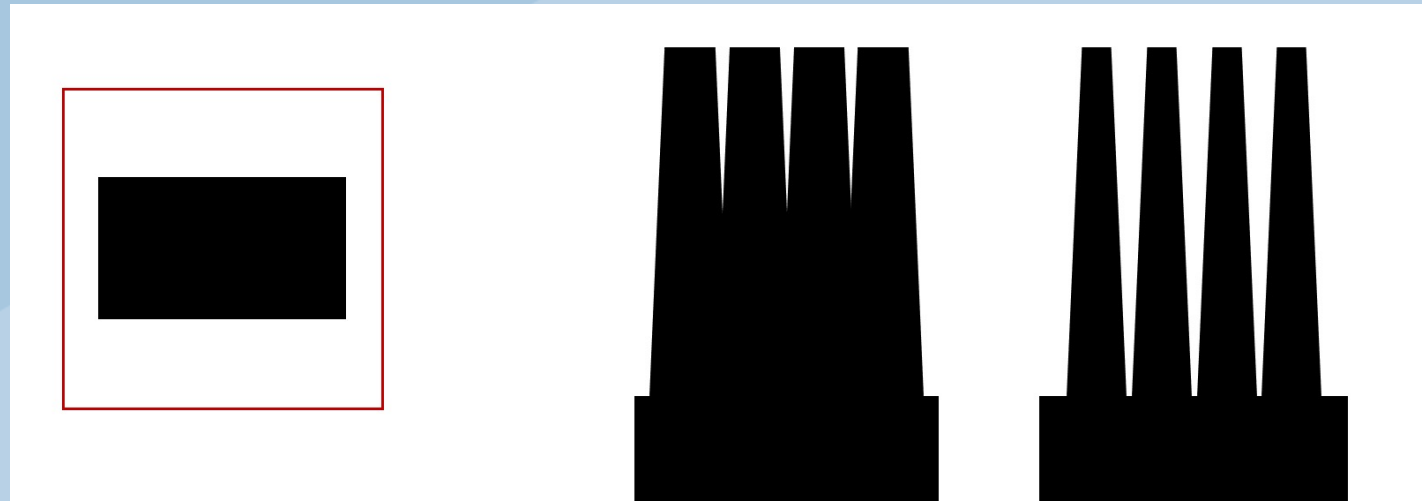


# New designs using metasurfaces



[Devlin 2017]

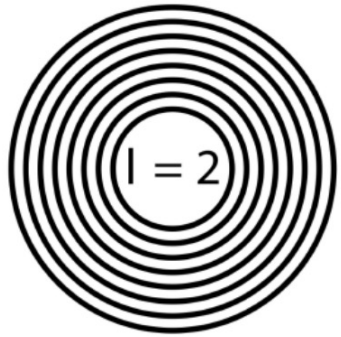
- new Degree of Freedom: height, width and length of the blocks



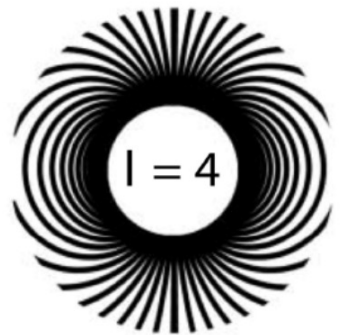
- it turns out that the optimal solution is close to continuous grating lines (AGPM)

# Pixelization approaches

ideal

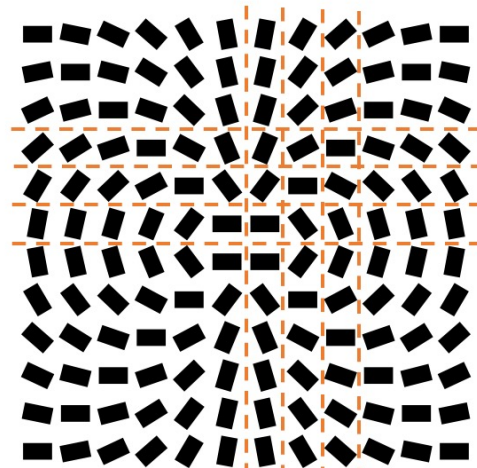
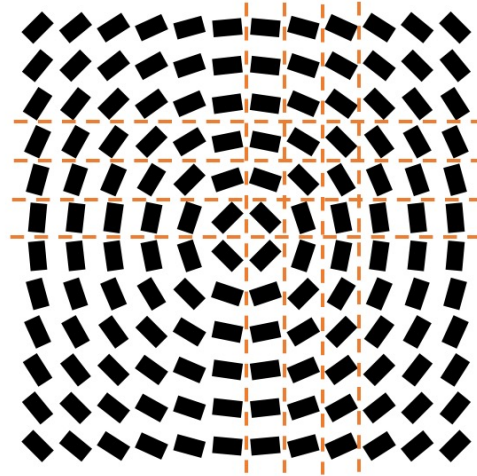


charge-2



charge-4

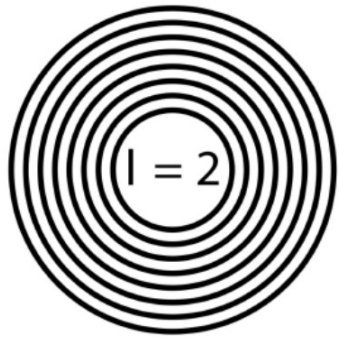
cartesian



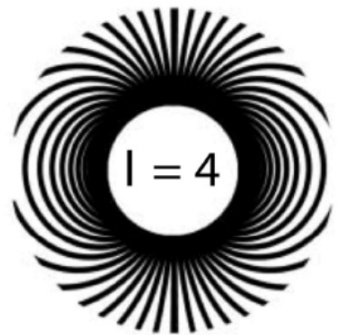


# Pixelization approaches

ideal

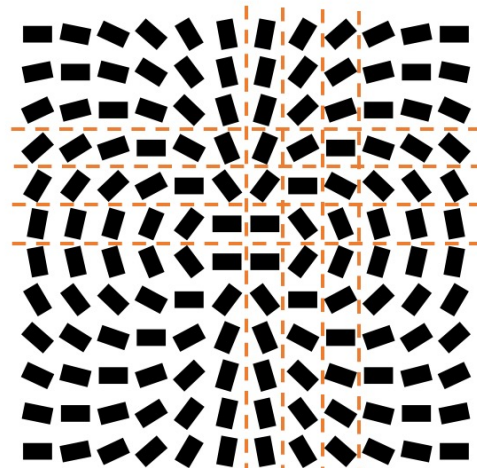
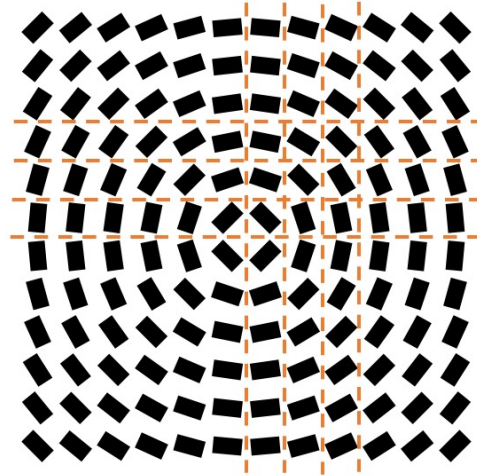


charge-2

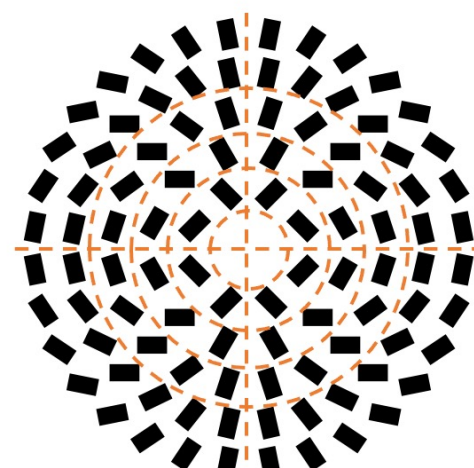
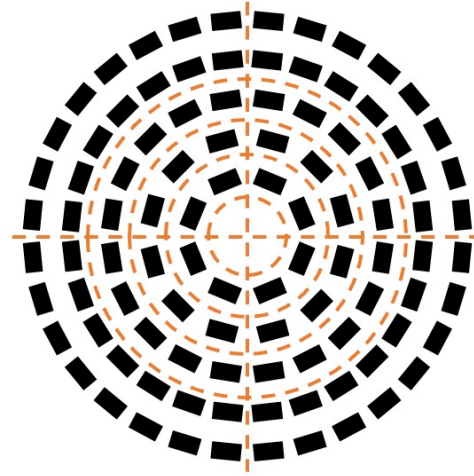


charge-4

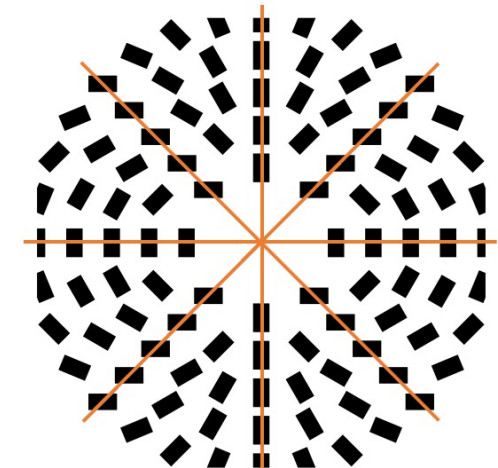
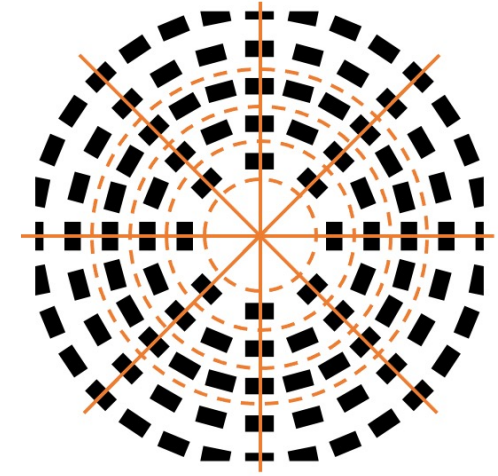
cartesian



polar

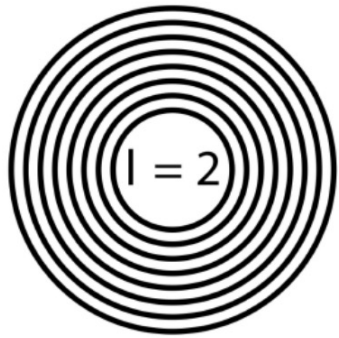


polar sym.



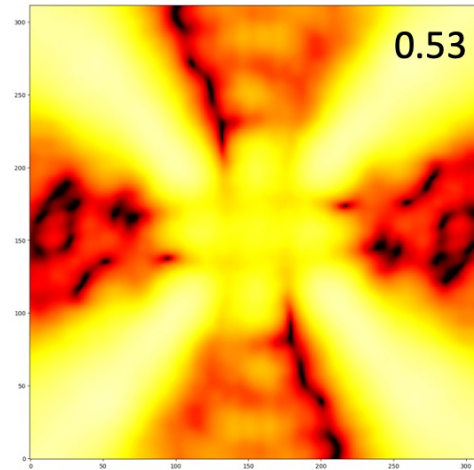
# Pixelization approaches

ideal

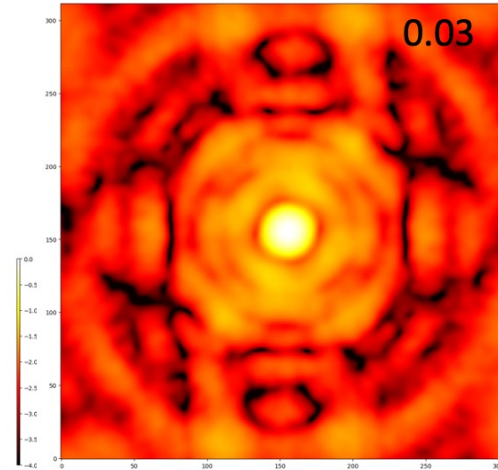


charge-2

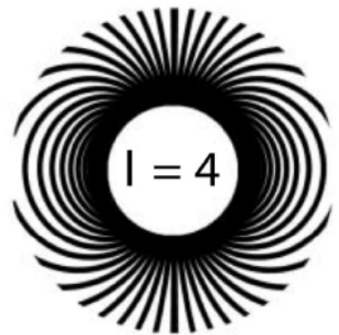
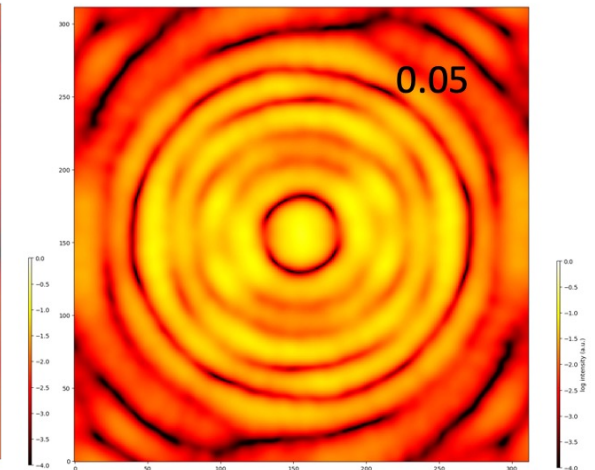
cartesian



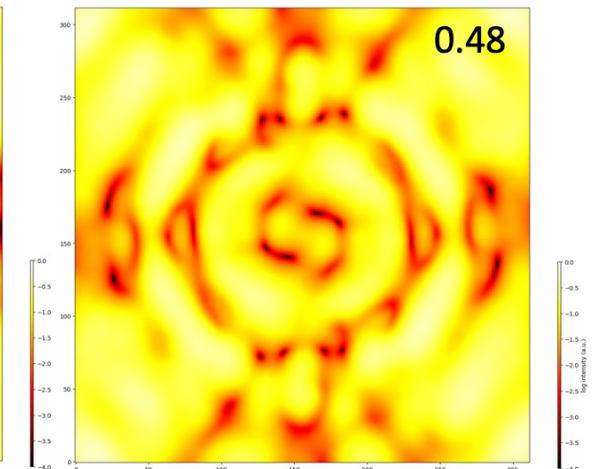
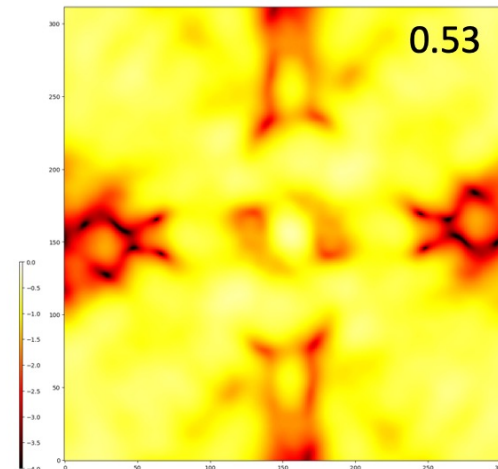
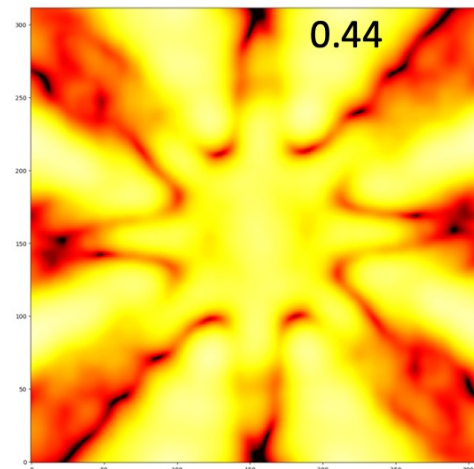
polar



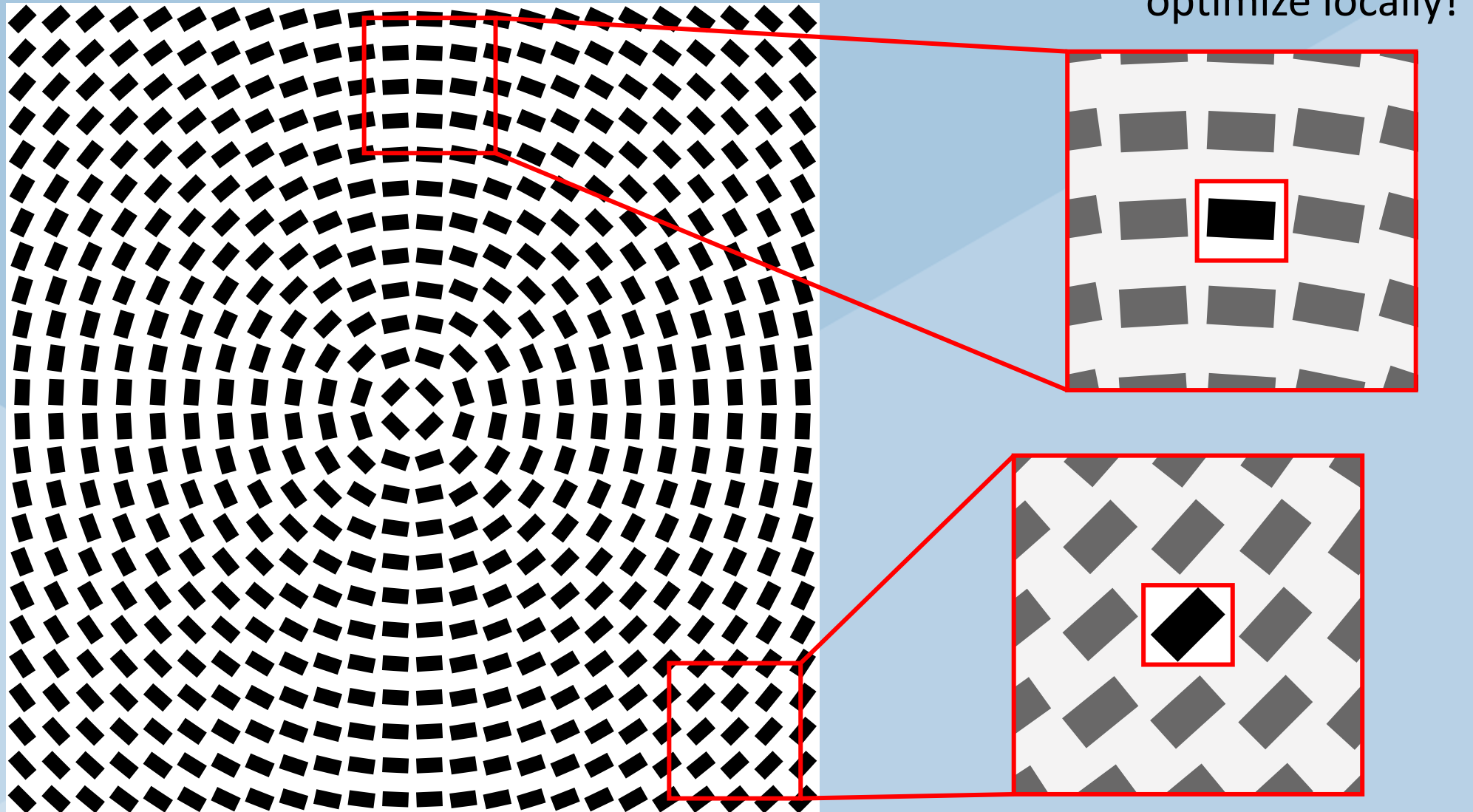
polar sym.



charge-4



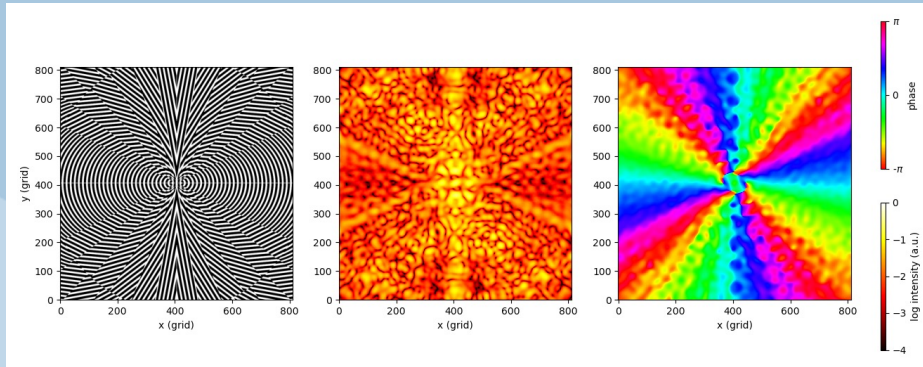
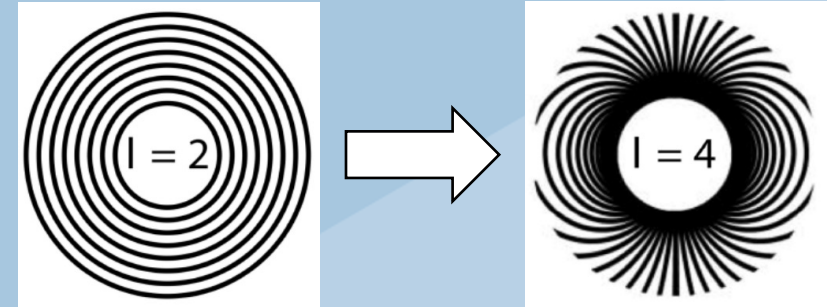
# Adapted cartesian pixelization





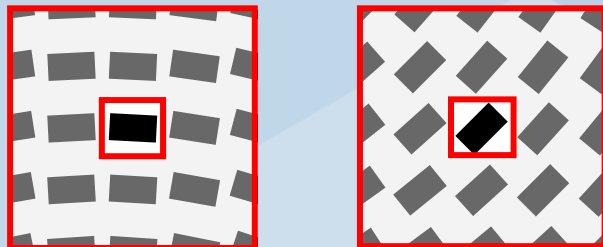
# Conclusion

Need for higher topological charge:  
low-order aberrations and resolved stars



FDTD simulations of full patterns

Metasurfaces provide an exciting new path



local optimization of the block parameters

