

JPL/Princeton TPF Review

Pupils: Masking vs. Mapping

Robert J. Vanderbei

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Princeton University

<http://www.princeton.edu/~rvdb>

Summary

- Much of our work involves designing pupil masks.
- We have proposed several designs (multipupil, concentric ring, starshape, barcode, checkerboard).
- We plan to design new masks— 10^{-7} , smaller iwa, more openings, etc.
- However, much of this past year has been about diffraction analyses of our lab and of pupil mapping.
- **The Big Question: Which is better, shaped pupils and pupil mapping?**



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Apodization/Masking



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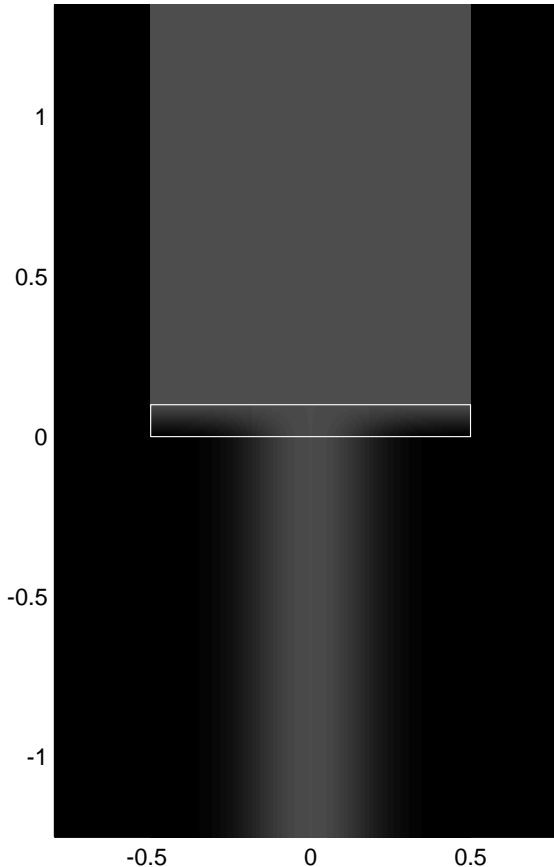
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Advantages:

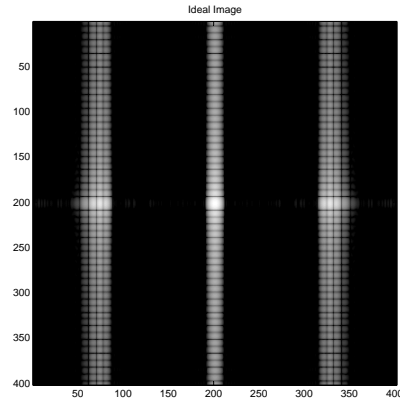
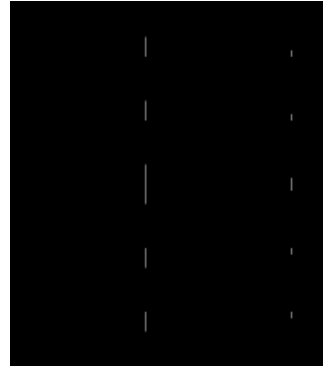
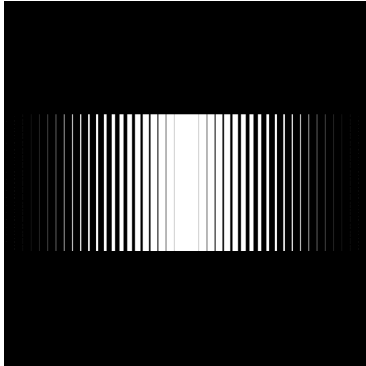
- Manufacturable!!!
- Achieves 10^{-10} contrast.

Disadvantages:

- Throughput is 10%.
- Best inner working angle is $4\lambda/D$.



One New Mask



3.5×8 , 0.5 rounded corners, $iwa=4.1\lambda/D$,



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Pupil Mapping

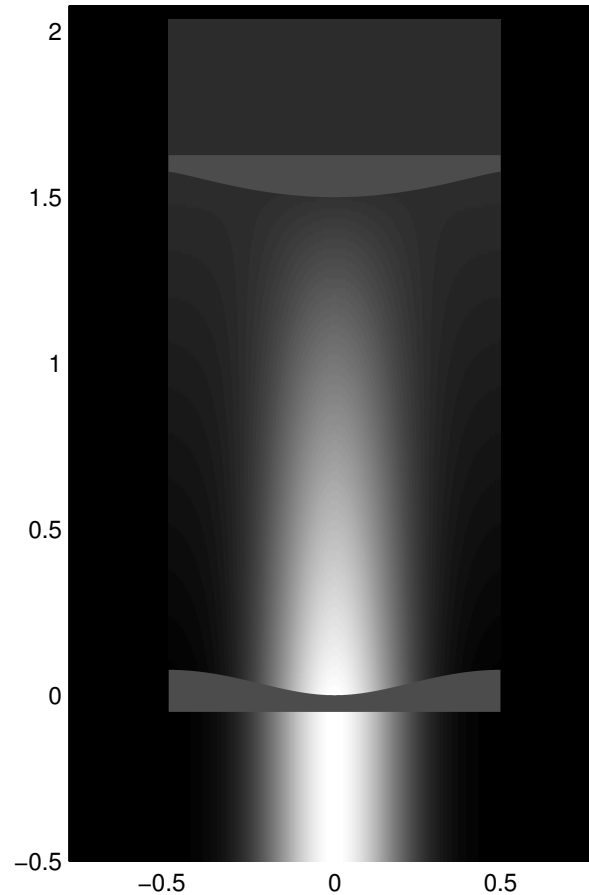


Advantages:

- 100% throughput
- Implicit magnification... effectively $iwa \approx 1\lambda/D$.

Disadvantages:

- Diffraction effects limit achievable contrast to 10^{-5} for a pure pupil-mapping system—a hybrid system is required.
- Hybrid system is inherently chromatic.
- Unmanufacturable?



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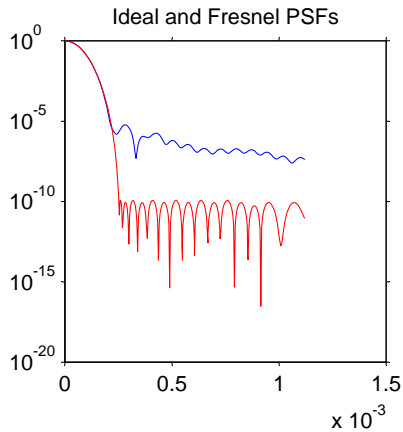
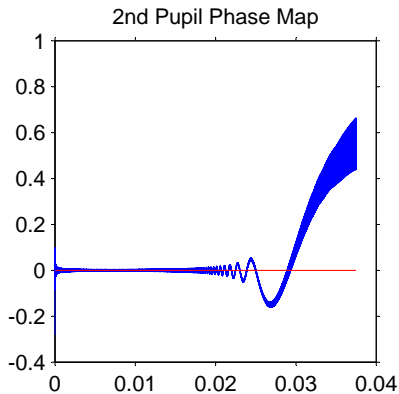
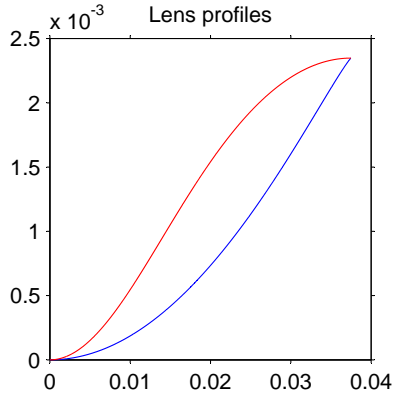
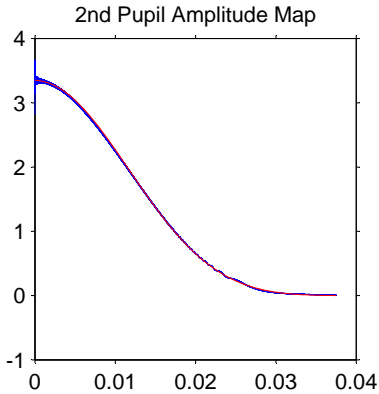
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Pupil Mapping for High Contrast (PIAA)



$n = 1.5$. $D = 75\text{mm}$. $z = 5D$. $\lambda = 632.8\text{nm}$.
Designed for 10^{-10} . Delivers 10^{-5} .



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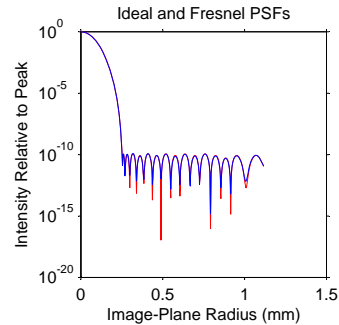
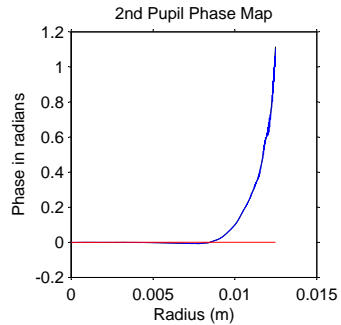
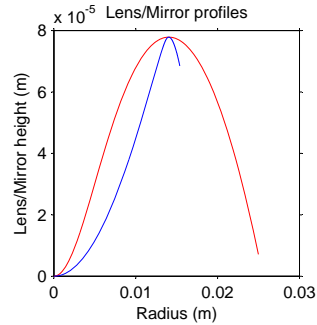
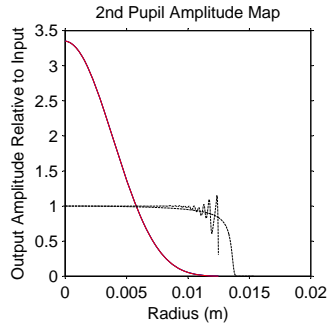
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Using a pre- and post-apodizer...

... and a post-phase-shifter



This is a mirror design.



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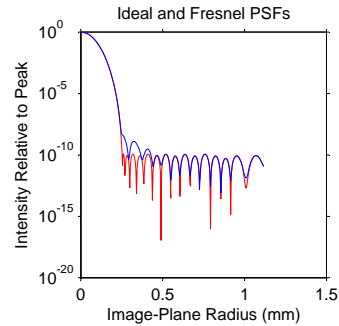
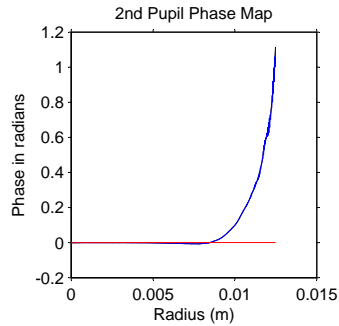
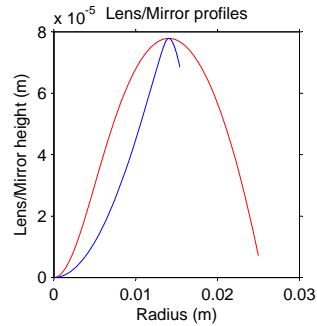
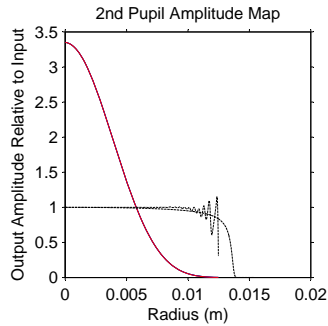
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Wavelength Dependence



Changed wavelength by 10%.



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Conclusion

Advantages:

- Manufacturable!!!
- Achieves 10^{-10} contrast.

Disadvantages:

- Throughput is 10%.
- Best inner working angle is $4\lambda/D$.

Advantages:

- 100% throughput
- Implicit magnification... effectively $iwa \approx 1\lambda/D$.

Disadvantages:

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