Principle, simulations and laboratory results of the Self-Coherent Camera

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Exoplanets imaging

SPHERE (VLT)

XAO + coronagraph + differential imaging :

at 5λ/D accessible contrast~5.10e-5 in H band in 20min.

ONE OF THE MAIN LIMITATIONS

Quasi static wavefront aberrations => quasi-static speckles

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NEEDS

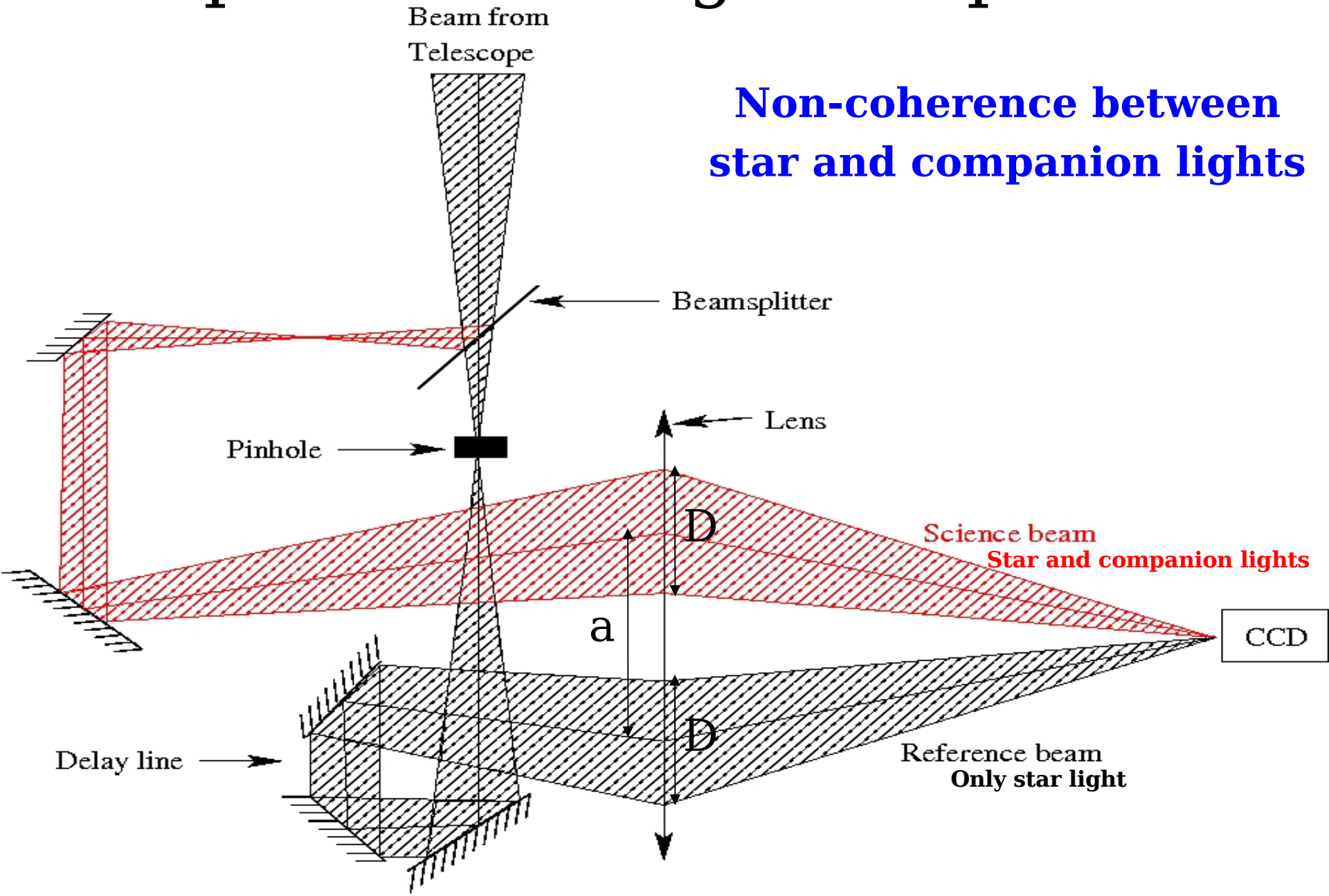
Calibrate and eliminate these speckles

PROPOSITION

The Self-Coherent Camera (Baudoz 2006) based on the

non-coherence between star and companion lights

Step 1 : encoding star speckles



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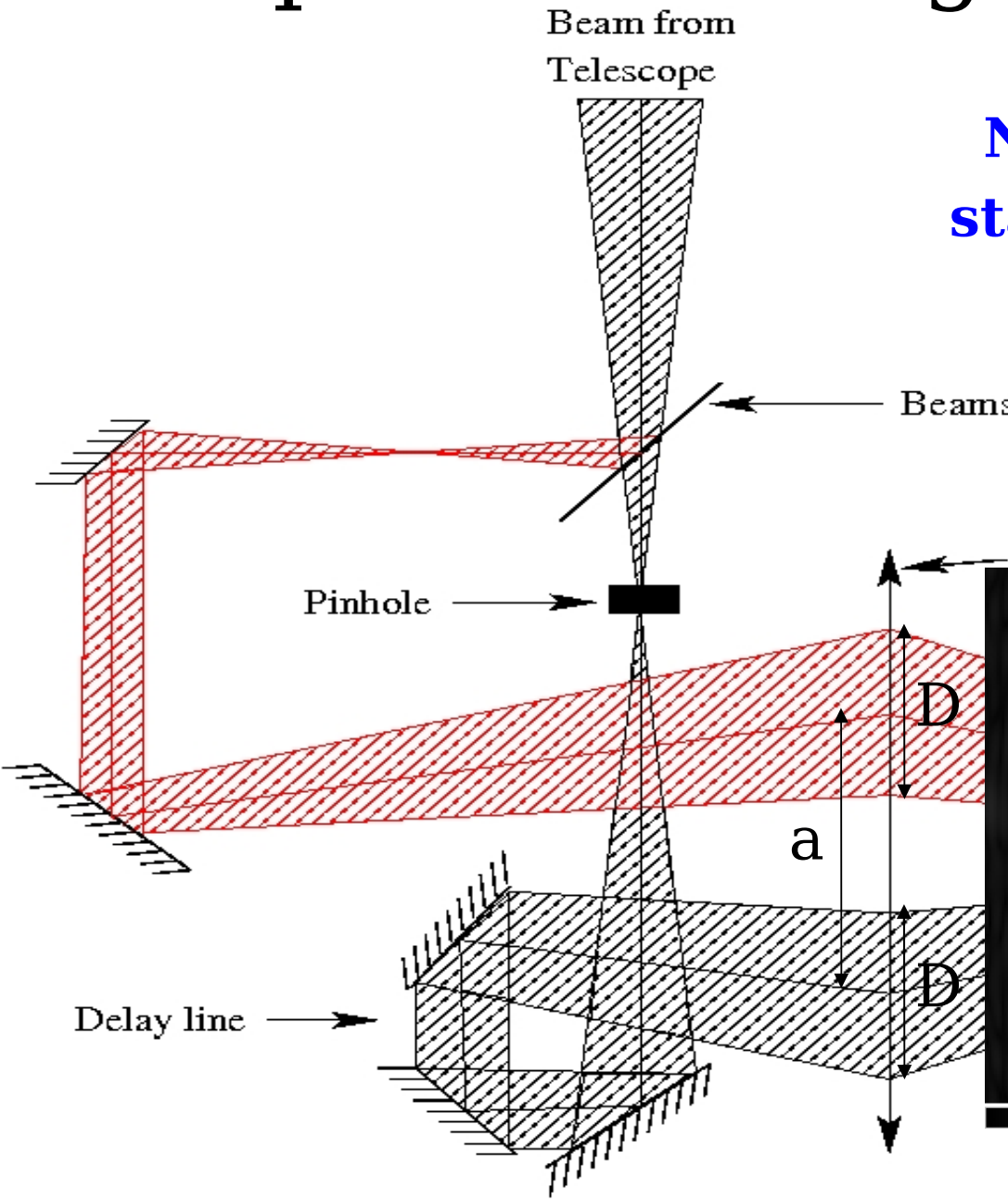
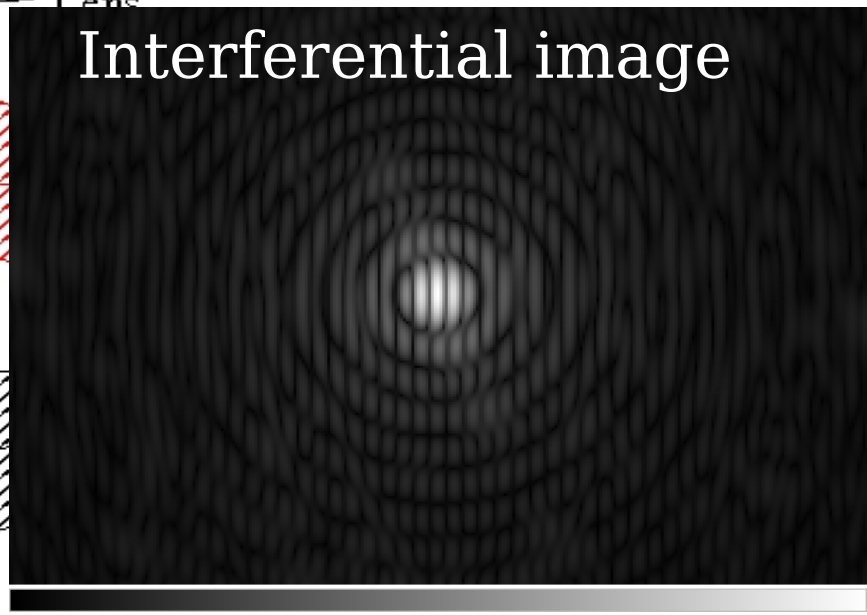


Non-coherence between star and companion lights



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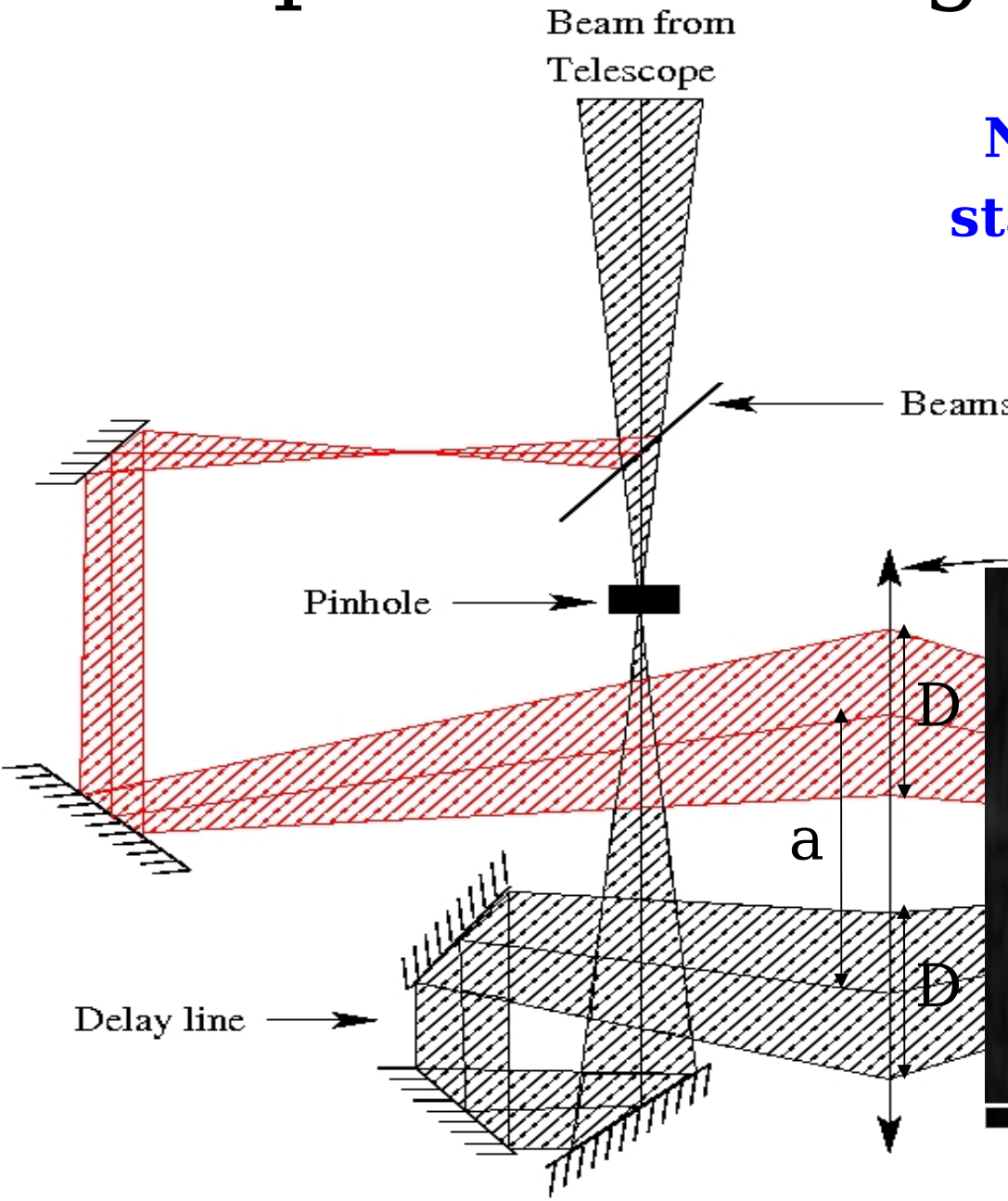

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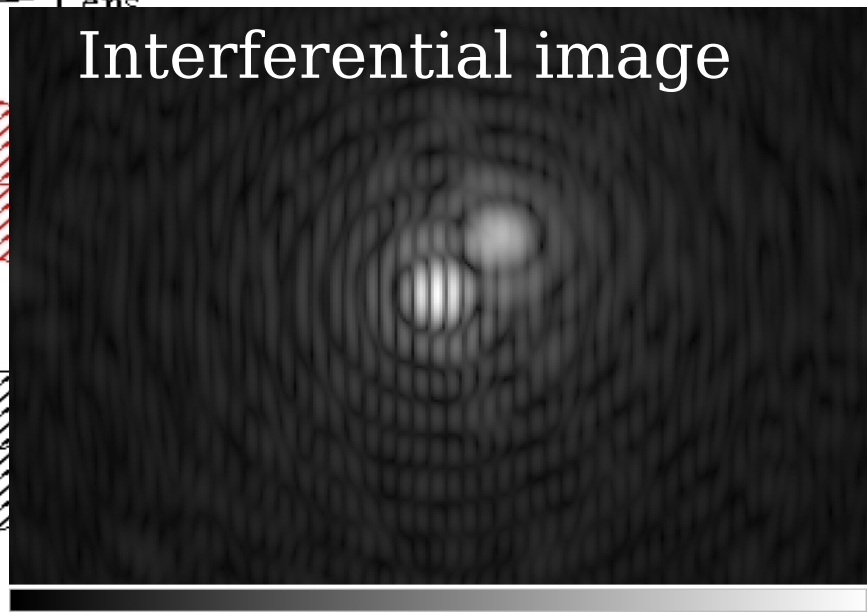
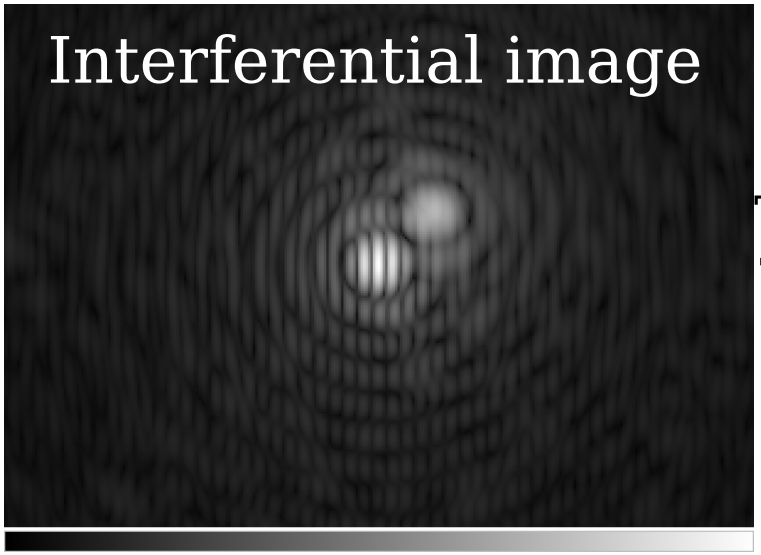
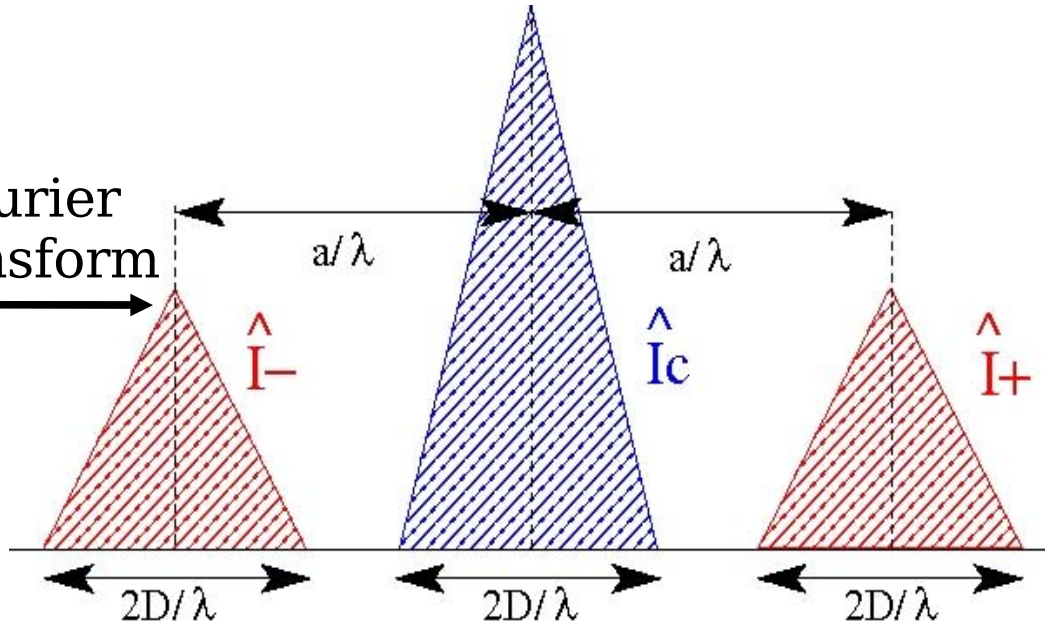


Step 2 : Image analysis



Fourier Transform



speckles information in I+ and I-

companion information in Ic

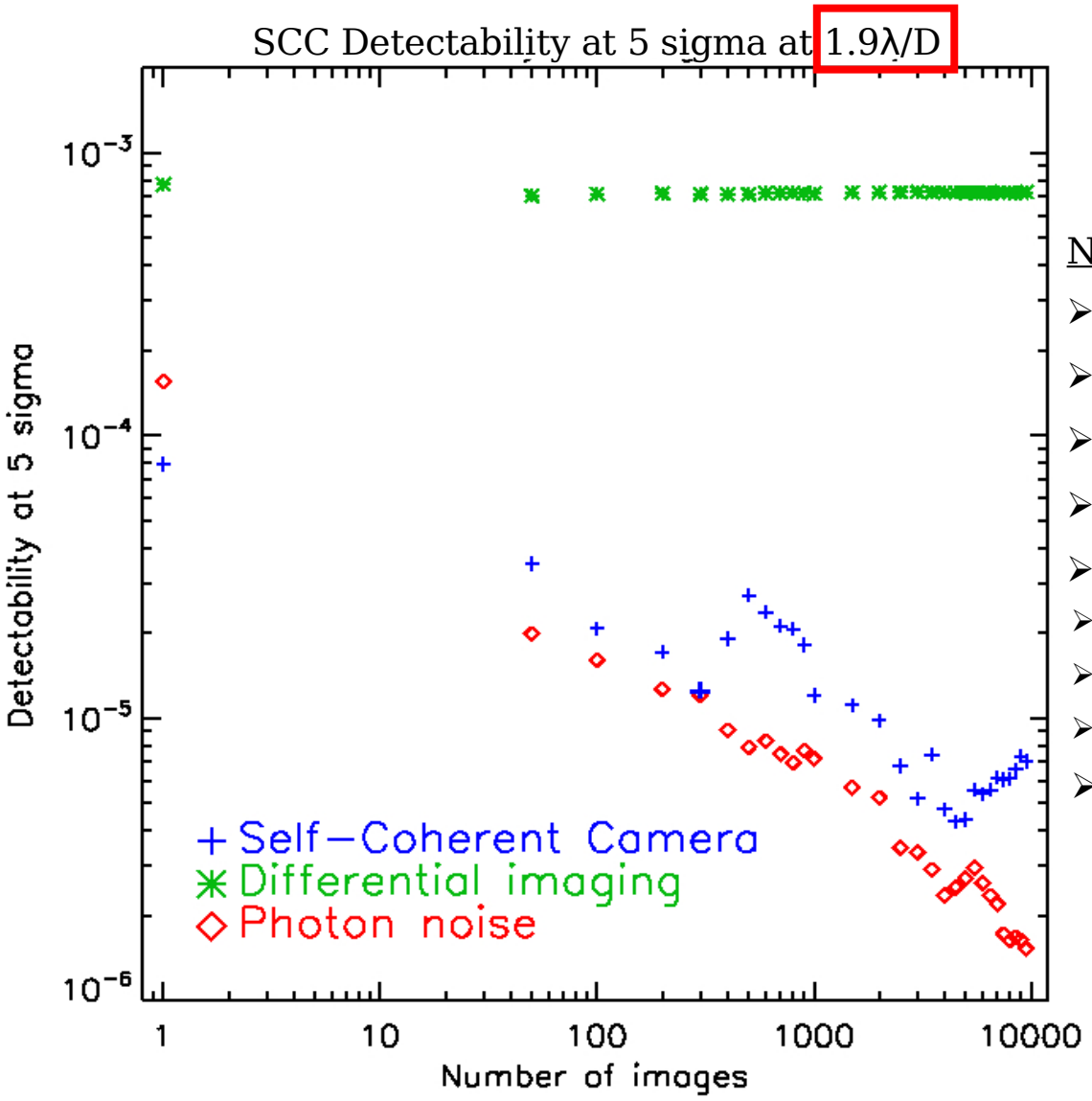
Companion image estimator

$I_{estimator} = I_c - I_R - (I_- I_+ / I_R)$

Rq : I_R is the reference beam image

companion + frozen speckles

Companion detectability



Numerical simulations assumptions :

- Visible : λ=0.8μm.
- Common static aberrations : 10nm.
- Non-common static aberrations : 5nm.
- Photon noise; no Read-out-noise.
- XAO : S=75%.
- 8m telescope.
- 5th magnitude G-star.
- Beamsplitter 45/55
- R=8 (perfect chromatic compensator).

Galicher, Baudoz; "Expected Performance of a Self-Coherent Camera" accepted in *Report in Physics*, 2007.

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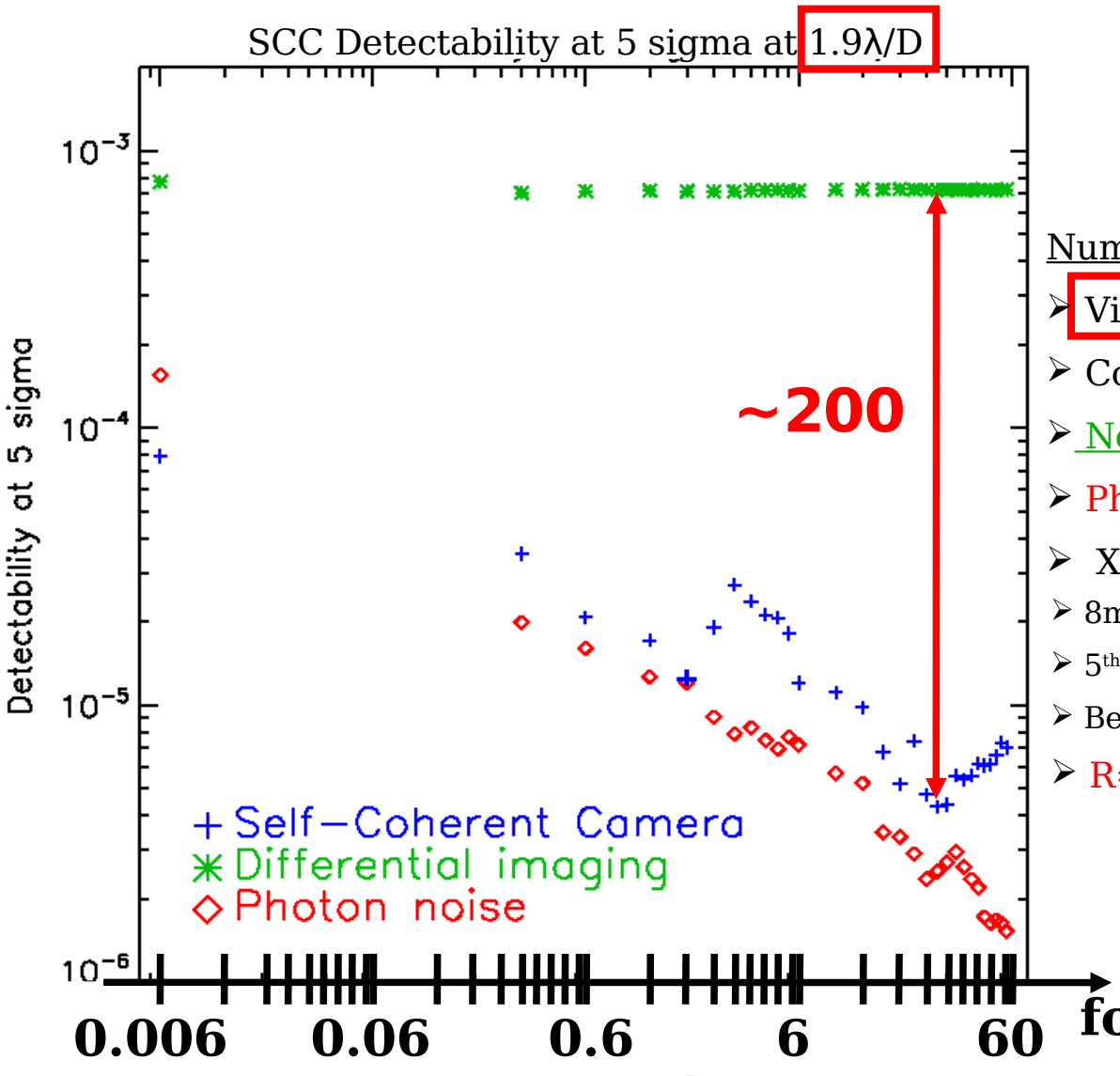

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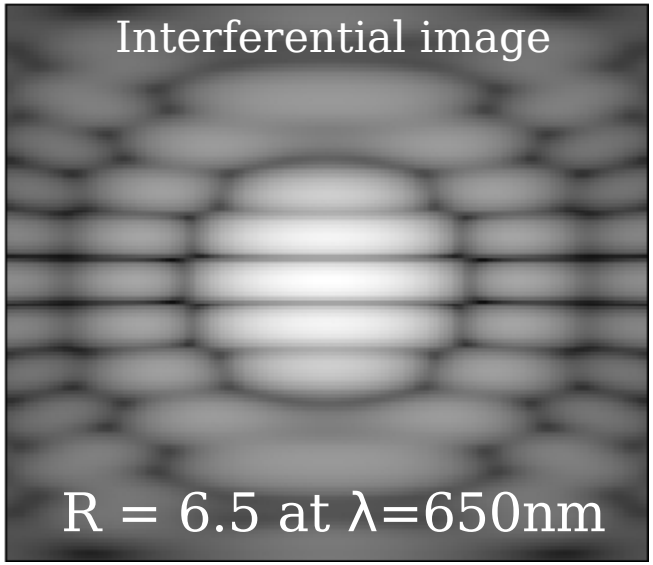
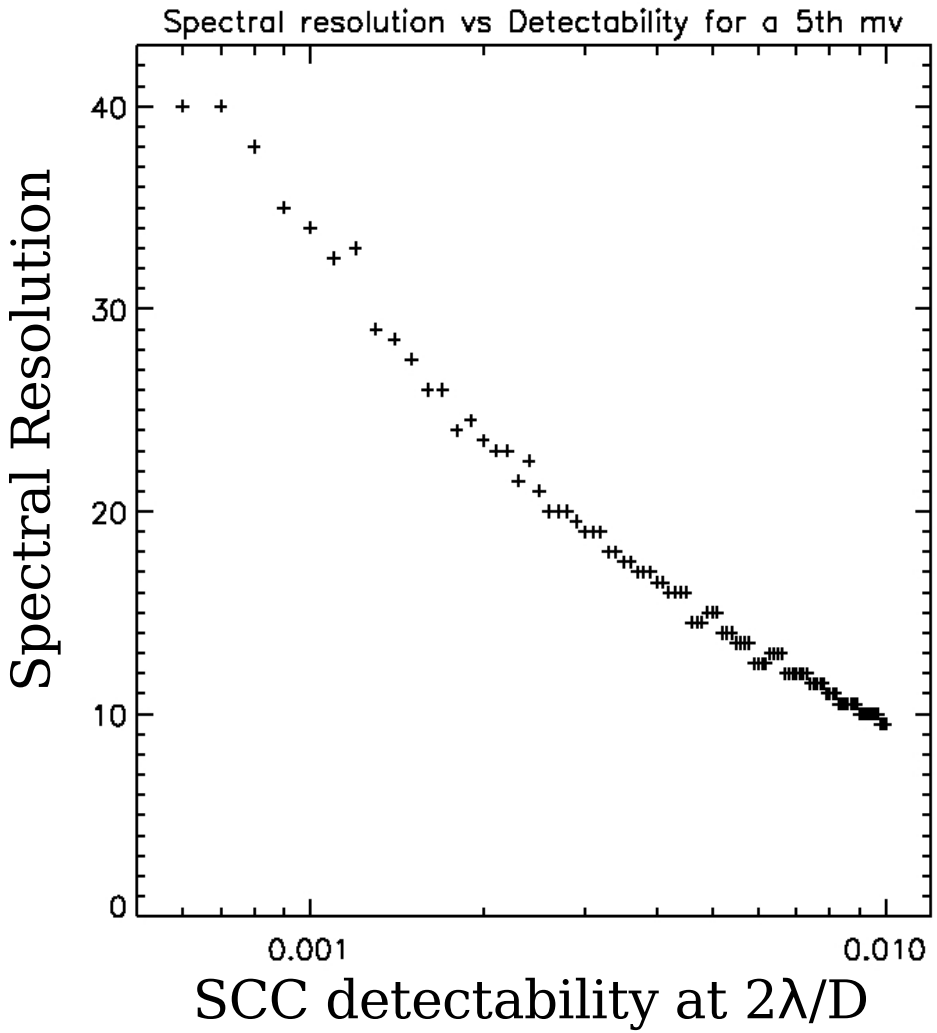
Polychromatic companion detectability





Numerical simulations assumptions :

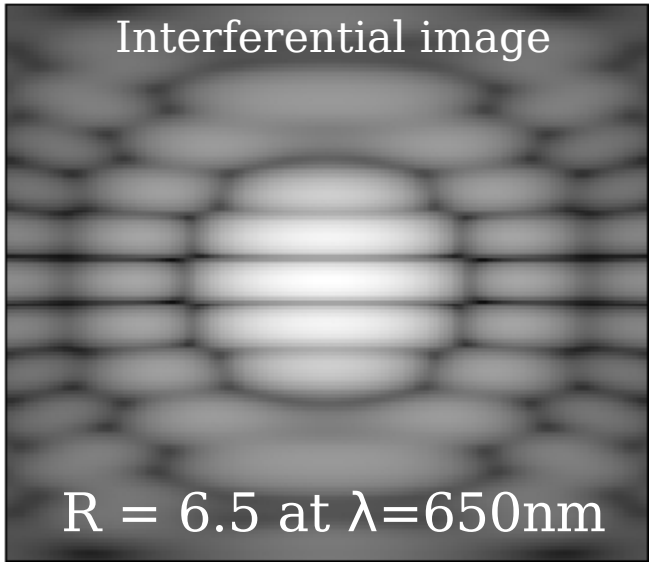
No atmospheric aberrations.
No Read-out-noise.
No static aberrations.

Photon noise.

λ = 650nm.

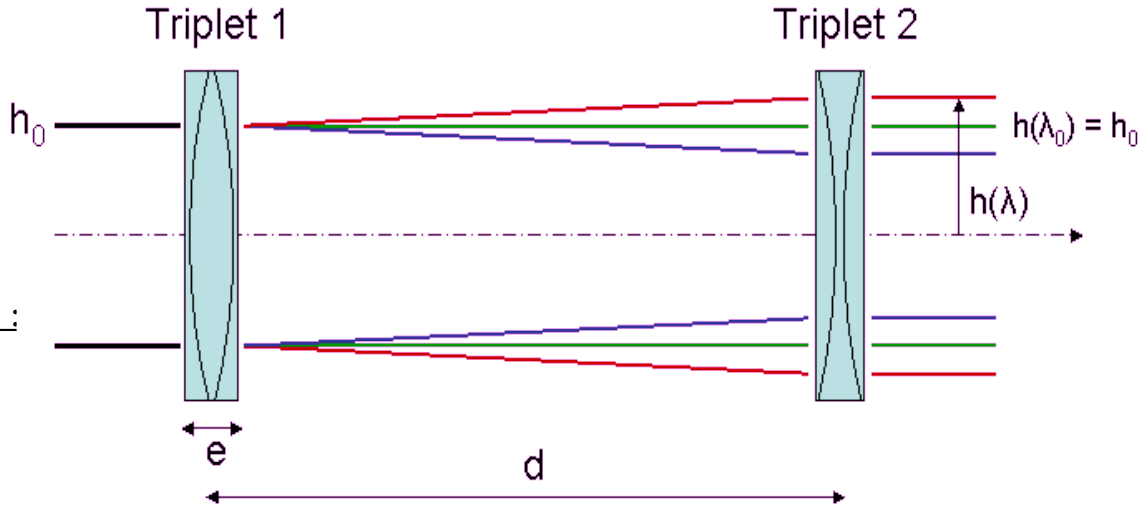
5th visible magnitude G2 star.

Polychromatic companion detectability



Chromatism is critic and has to be compensated

Solution : A Wynne compensator has been chosen



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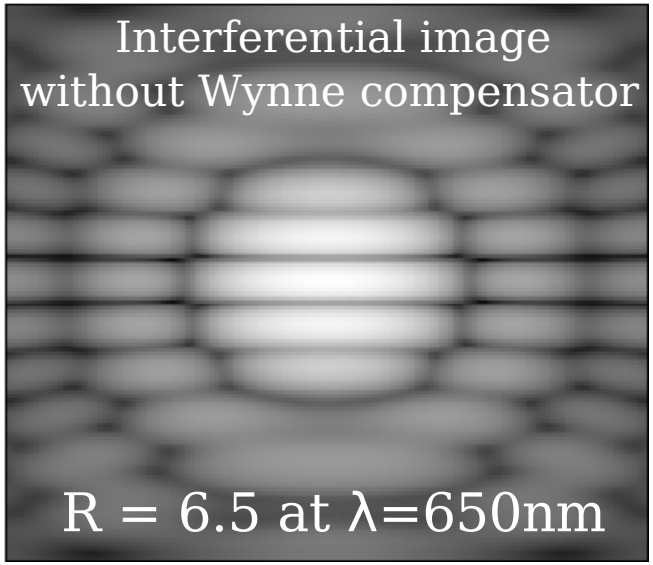

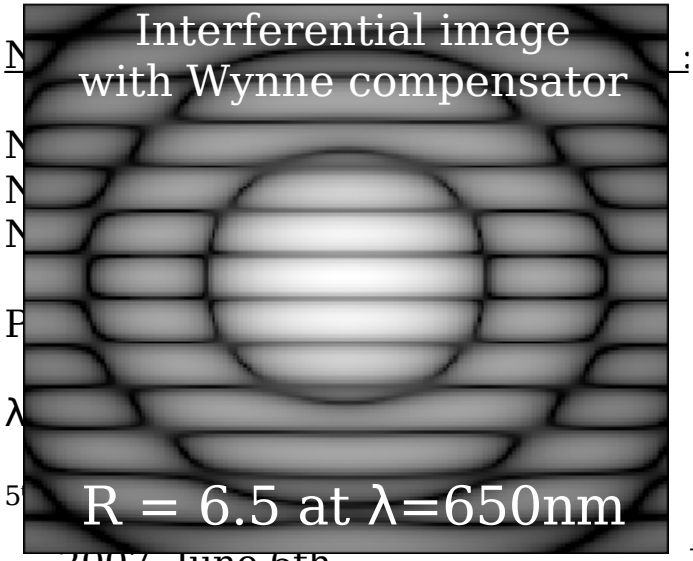

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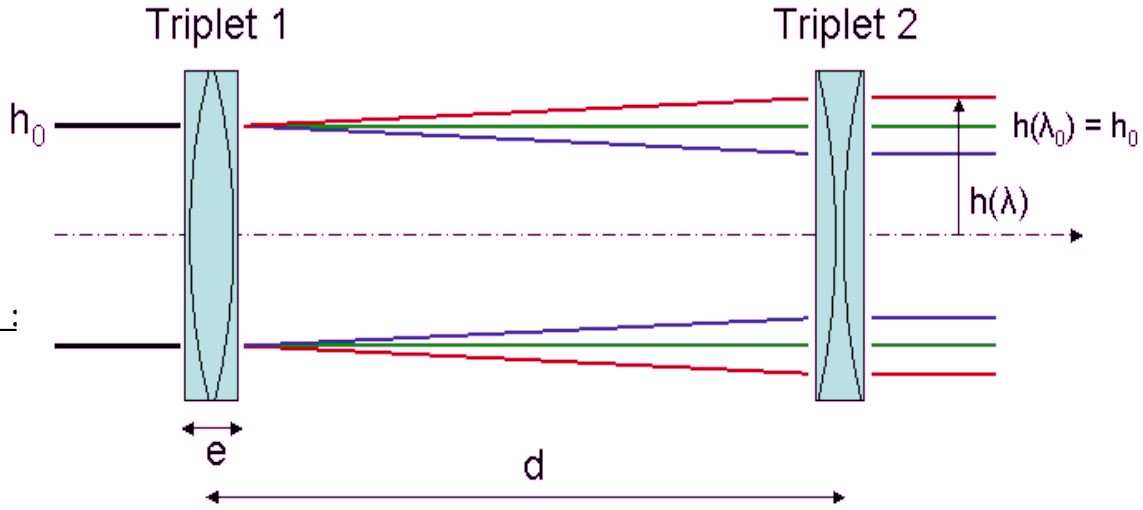
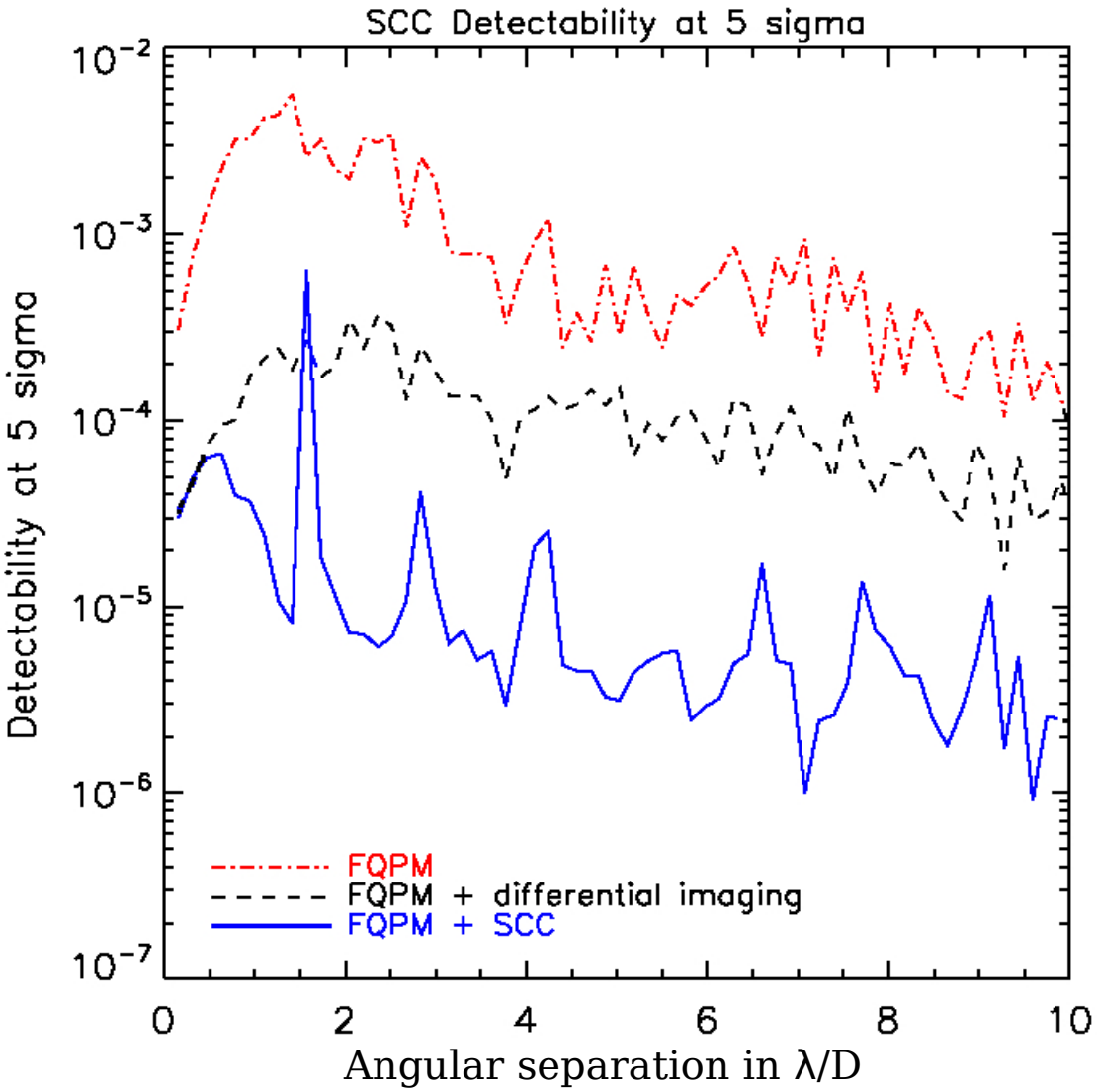


error between monochromatic and compensated images is ~ 0.75%

Companion detectability : SCC + Coronagraph



Numerical simulations assumptions :

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- Photon noise; no Read-out-noise.
- XAO : S=75%.
- 8m telescope.
- 5th magnitude G-star.
- R=8 (perfect chromatic compensator).
- Exposure time : 6ms (1 interferential image).

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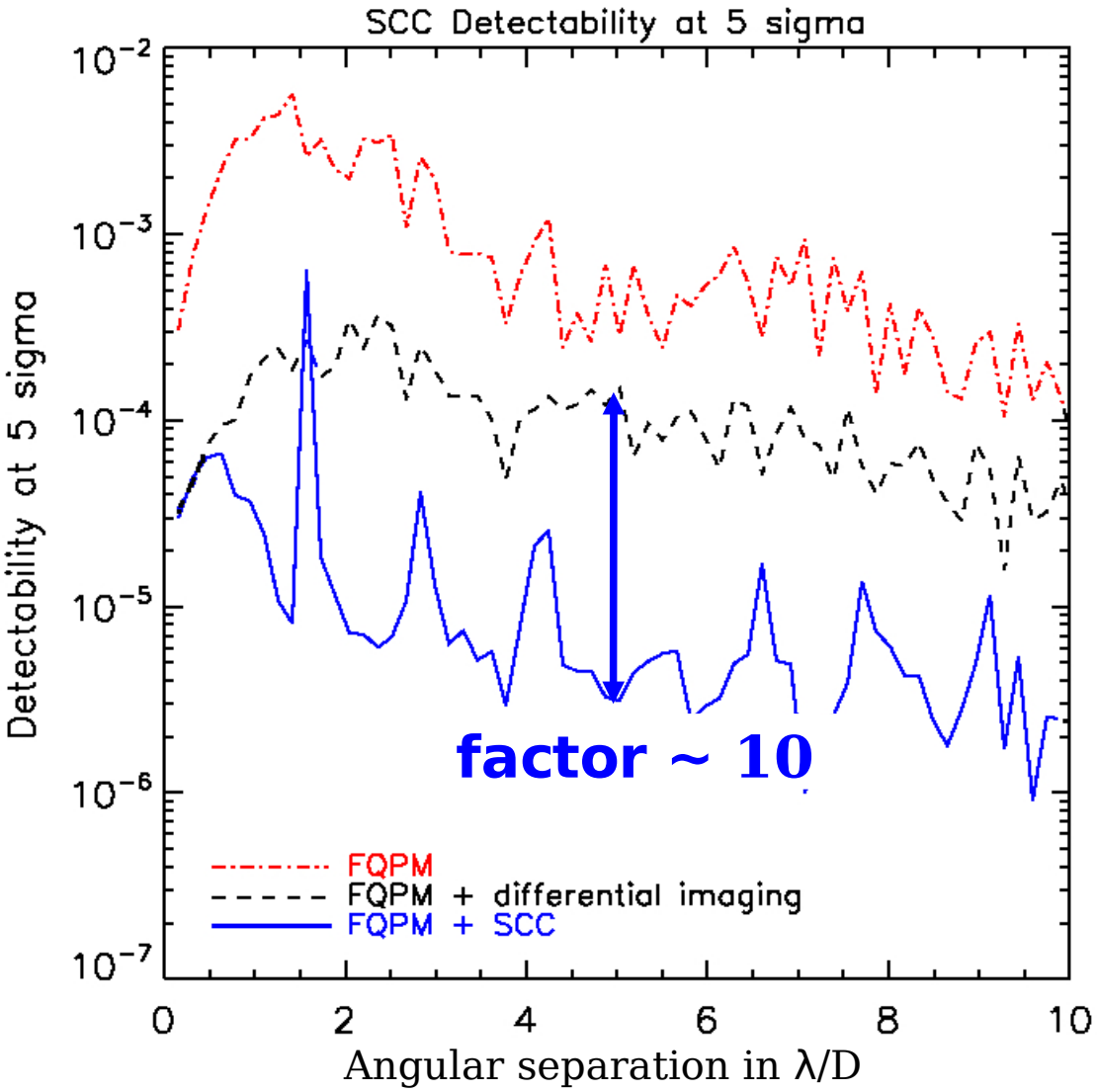

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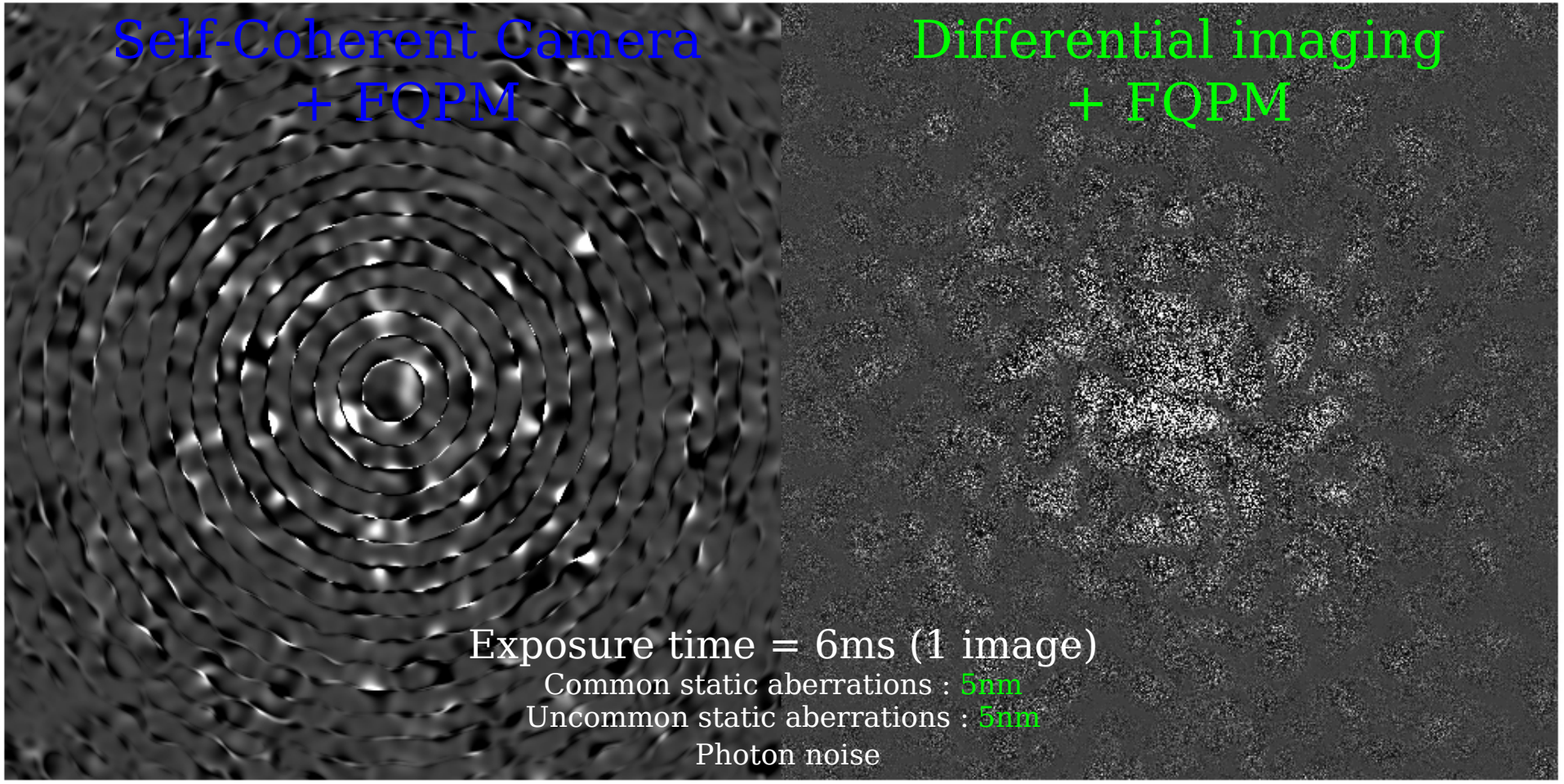

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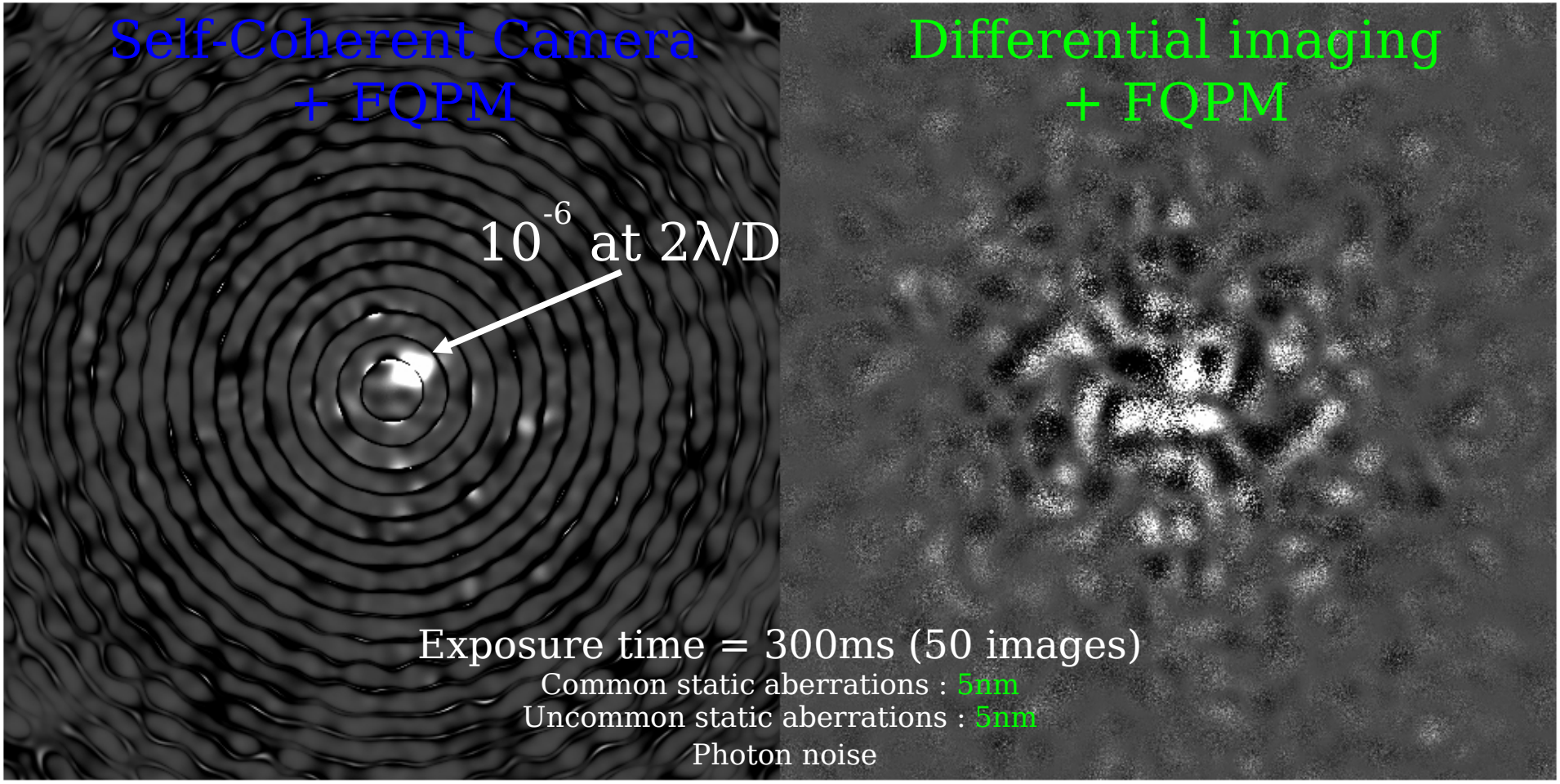
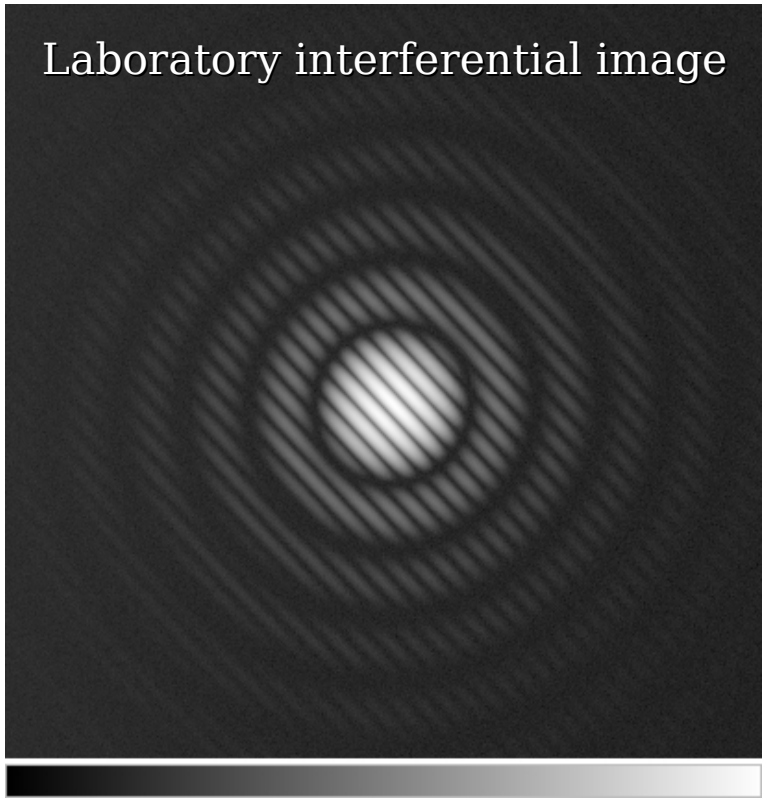
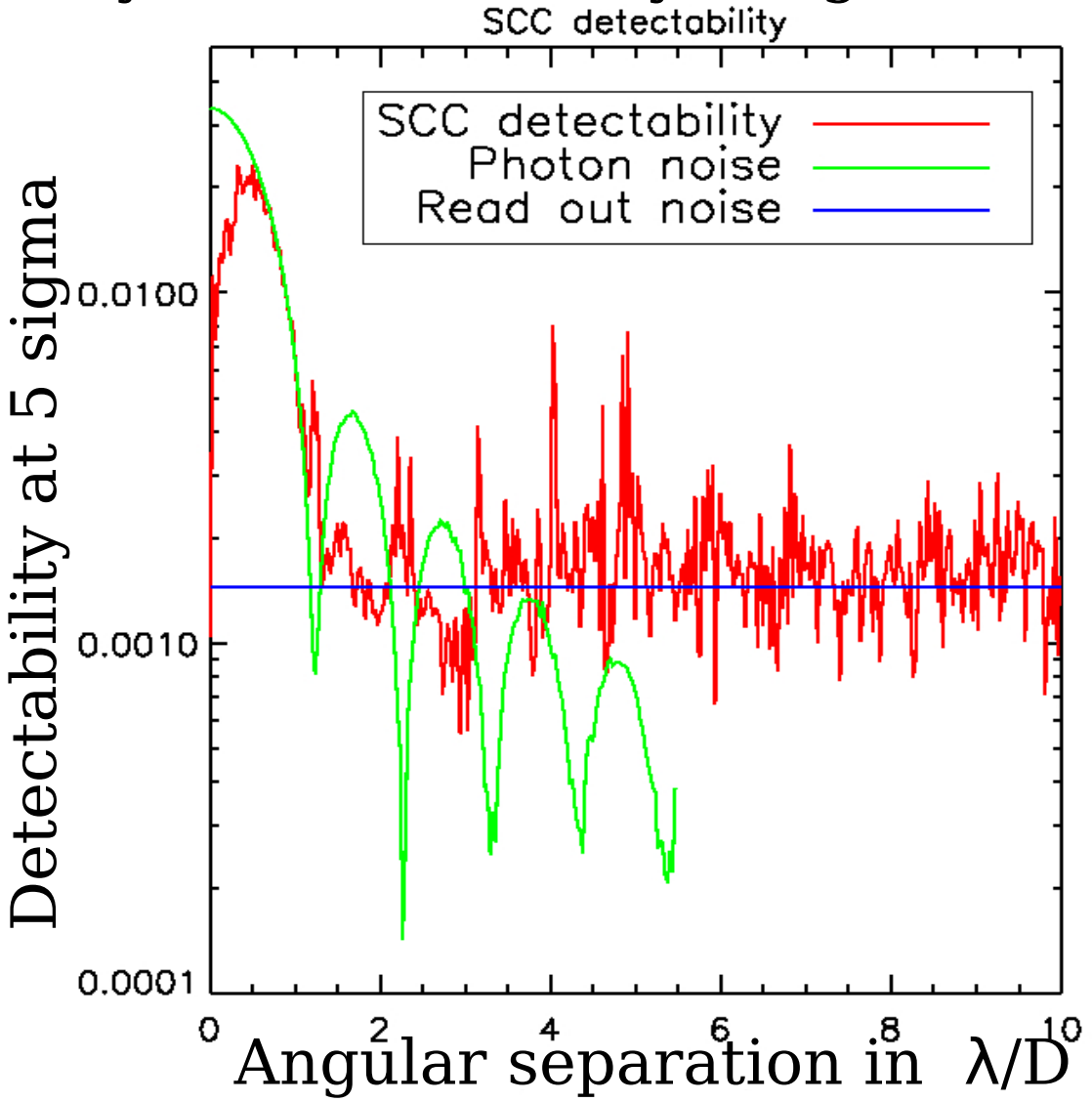


Laboratory preliminary results

Objectives :

Testing the image analysis on laboratory images





2007, June 6th

Conclusions and future studies

- Unlike differential imaging, the Self-Coherent Camera reaches photon noise.

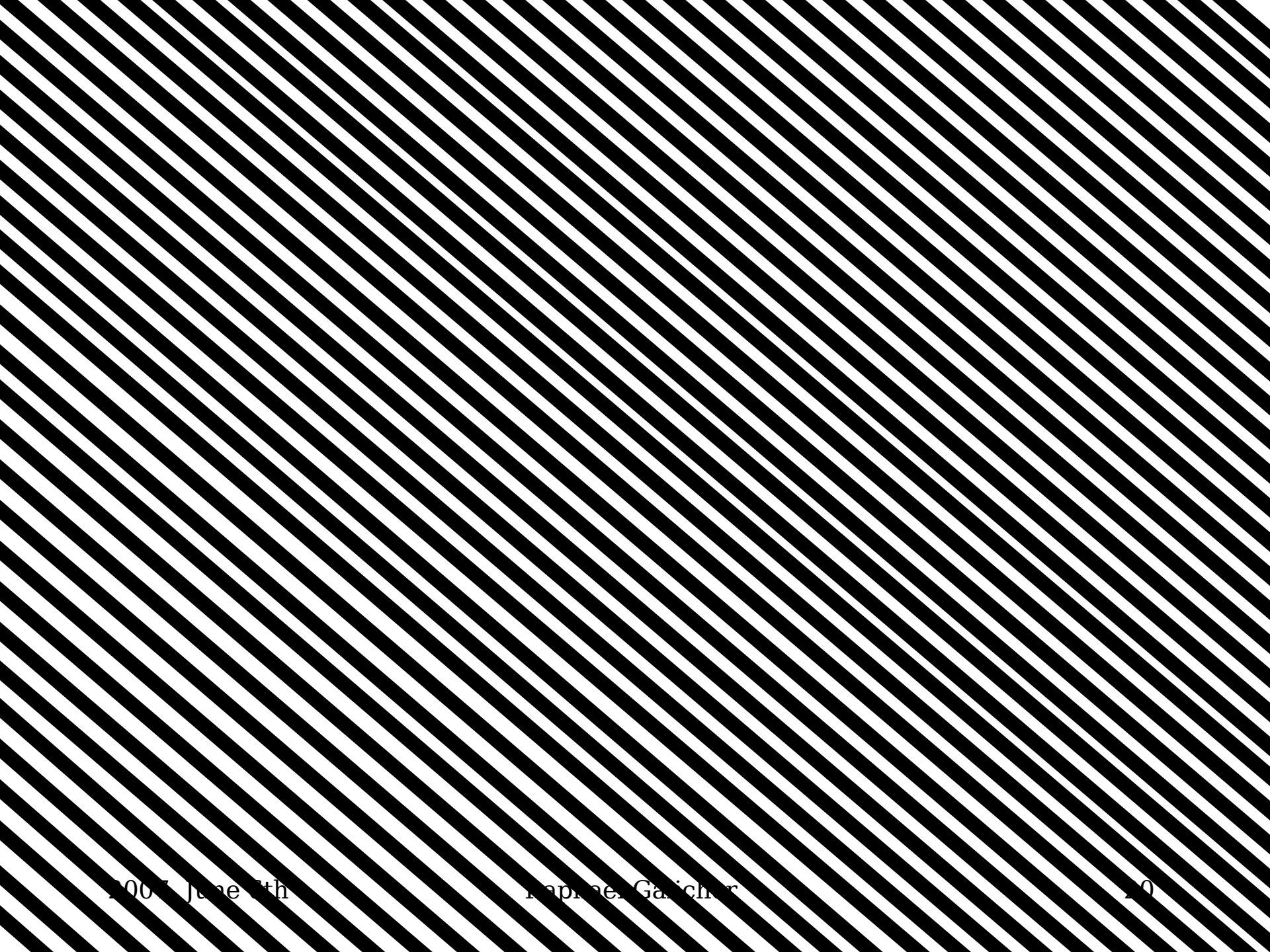
- The Self-Coherent Camera can be associated with a coronagraph :
  10^{-6} at $2\lambda/D$ in visible light (R=8) in a fraction of seconde from ground.

- Chromatic effects are not a limitation :
  Hardware solution : Wynne compensator enables R=6.5
  Software solution : A new estimator for polychromatic image is under study.

- More works are planned in the laboratory :
  a) Self-Coherent Camera.
  b) Self-Coherent Camera + coronagraph.
  c) Wynne compensator.

- Impact of Read-out-noise and new estimator.

- Use the Self-Coherent Camera to correct wavefront errors.



Coffee break begins now….

Thank you and

Thanks to Bernard Lyot