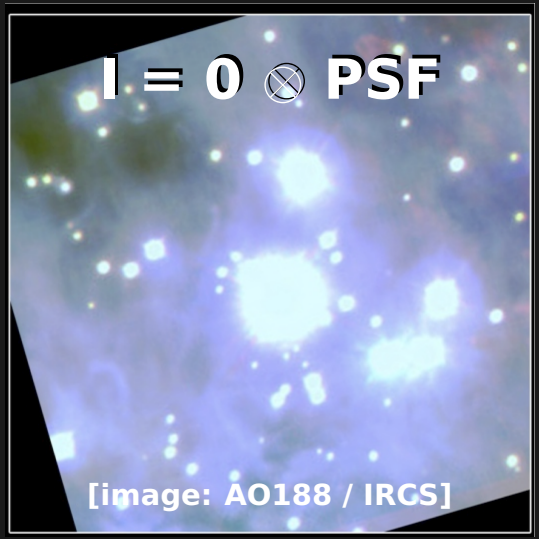
AO4ELT5 conference

Frantz Martinache

June 27, 2017

Interpreting images is the game



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Images dominated by diffraction

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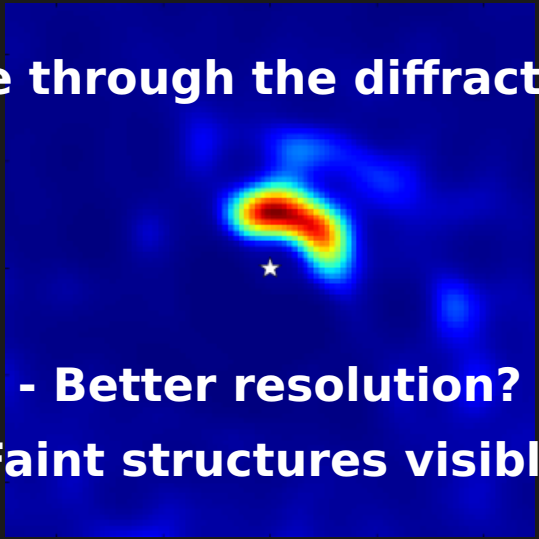
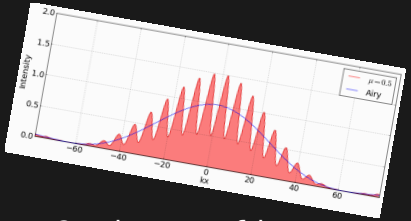


See through the diffraction

- Better resolution?

- Faint structures visible?

Interferometry: the diffraction queen



2-telescope fringes

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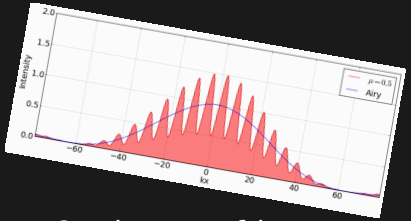

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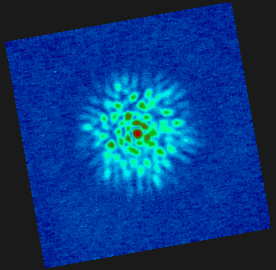

NRM-interferogram

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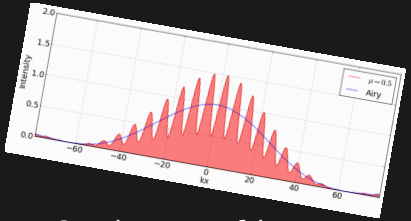

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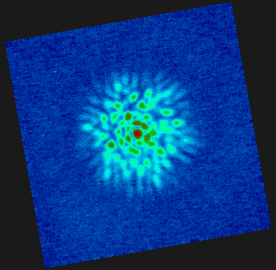

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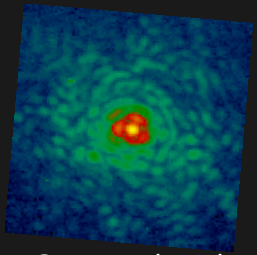
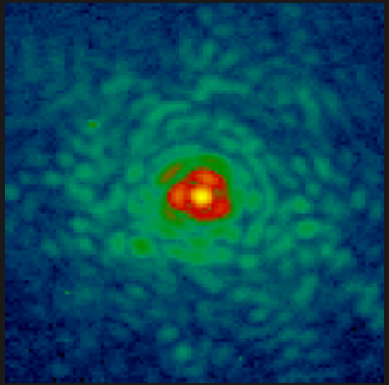


Conventional
AO-corrected image

The nutty idea:

Apply interferometry recipes to regular images.
Produce self-calibrating observables!

Understand images: crack the nut open



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permitted by
the KERNEL framework

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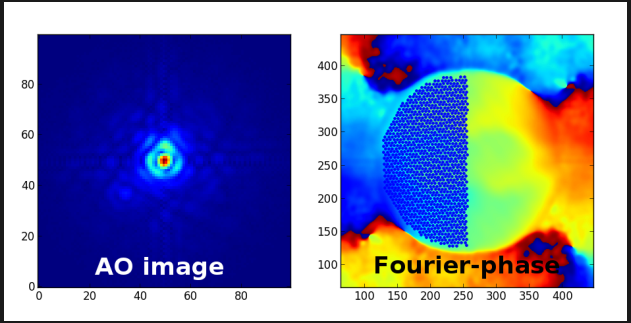
Martinache, 2010, ApJ, 724, 464
Martinache, 2013, PASP, 125, 926

Fourier analysis of "science" images

The principle:
Instead of direcly using images, focus on the phase part of their Fourier counterpart



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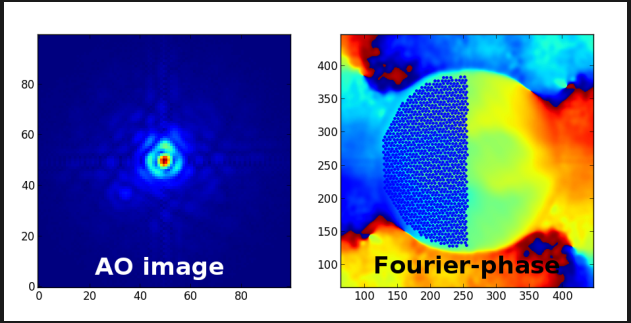
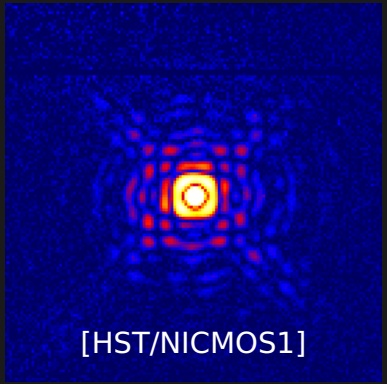


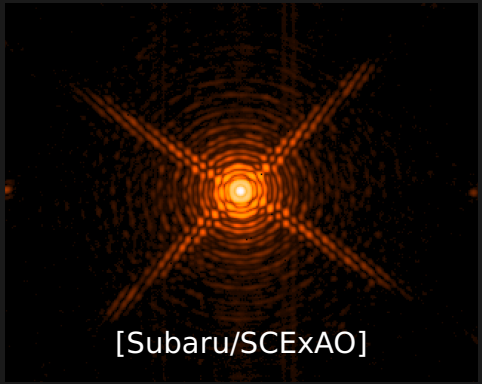
The convolution relation revisited

$$I = O \otimes PSF \Rightarrow \Phi = \Phi_0 + A \cdot \varphi$$

The ill-posed problem of image deconvolution becomes a well posed problem in terms of linear algebra

the catch: data requirements (for now)





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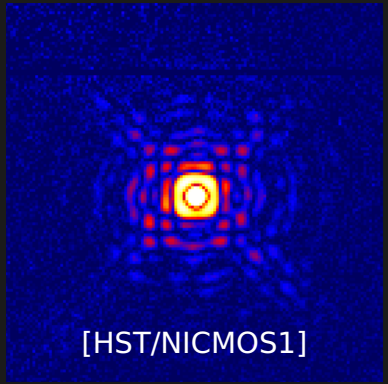

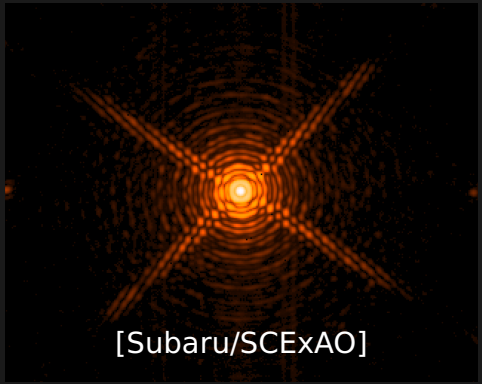

- #1 low-aberration regime (upstream AO required!)

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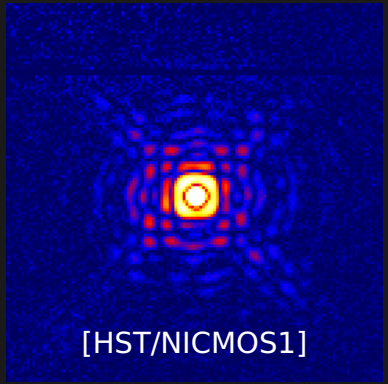

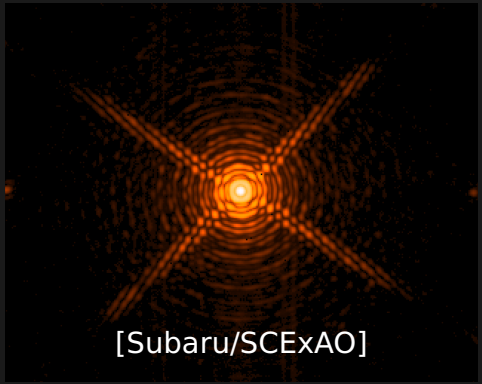

- #1 low-aberration regime (upstream AO required!)
- #2 unsaturated data (coronagraphy excluded!)

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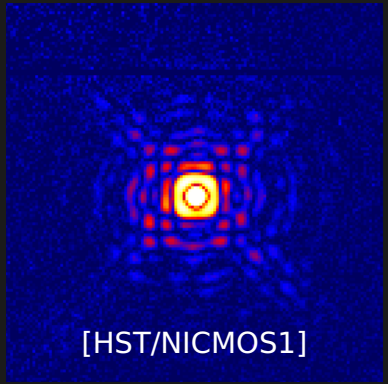
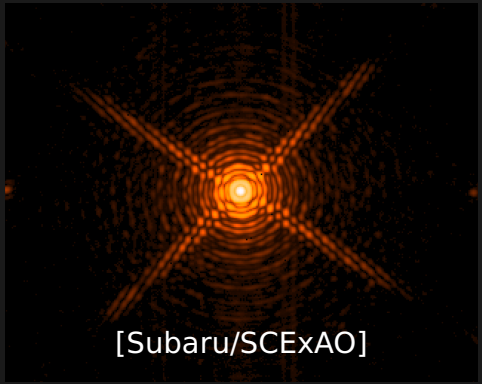


[HST/NICMOS1]

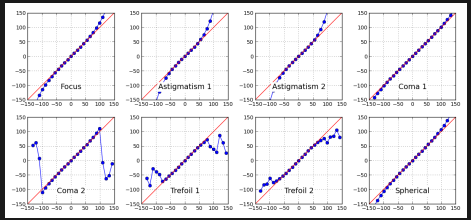


[Subaru/SCExAO]

- #1 low-aberration regime (upstream AO required!)
- #2 unsaturated data (coronagraphy excluded!)
- #3 well-sampled images (should be mandatory anyways)

not almighty yet but relevant already

Application to SCExAO



Use the science detector to correct the NCP error (low order modes)

The approach (H-band) is linear over a $\pm$ 200 nm range of aberration.

Martinache et al, 2016, AA, 593, A33

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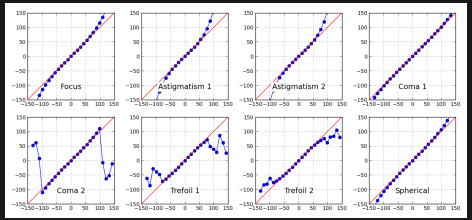

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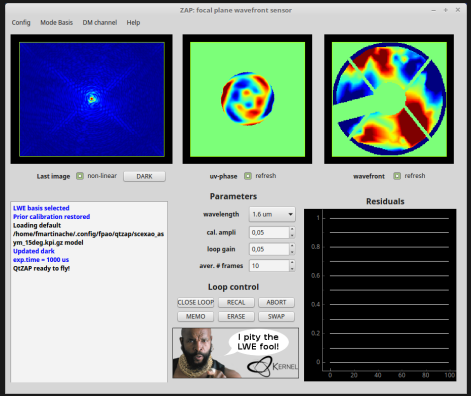
Closed-loop compensation of LWE



(talk by M. N'Diaye)

focal plane camera is the new WFS

"Give me a camera, sensitive and fast enough and a DM,
*and I shall beat the cr%p out of those bl**dy speckles!"*

- AOchimedes -

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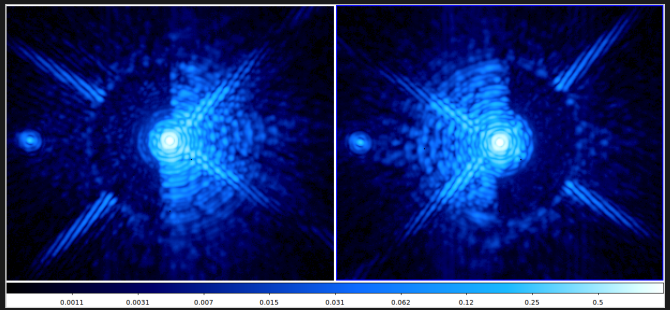

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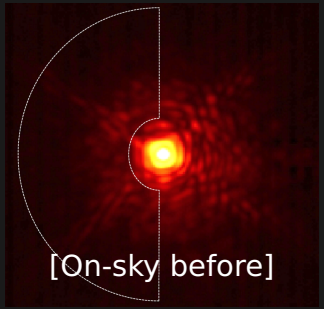
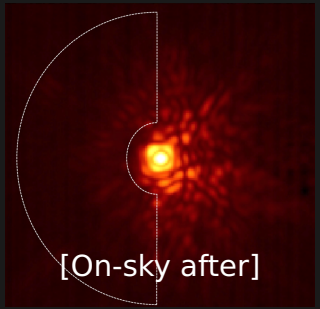
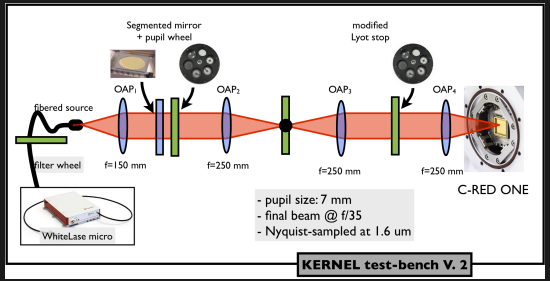


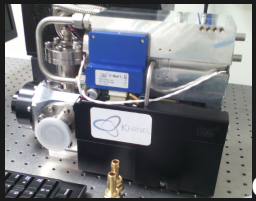


KERNEL: the right tools

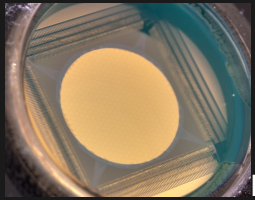
A portable instrument:

- Hex 507 segmented DM (BMC)
- C-RED-ONE IR camera (FLI)





C-RED-ONE



Hex 507

KERNEL: the right tools

A portable instrument:

- Hex 507 segmented DM (BMC)
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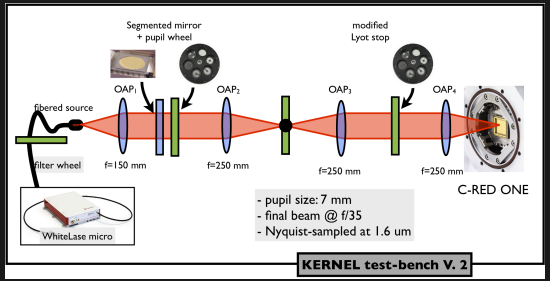
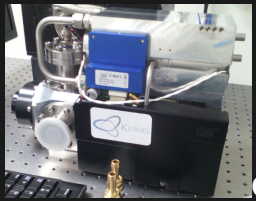
- Hunt down systematics





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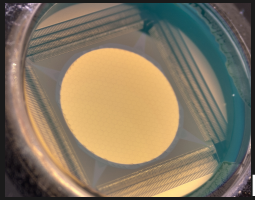

Hex 507

KERNEL: the right tools

A portable instrument:

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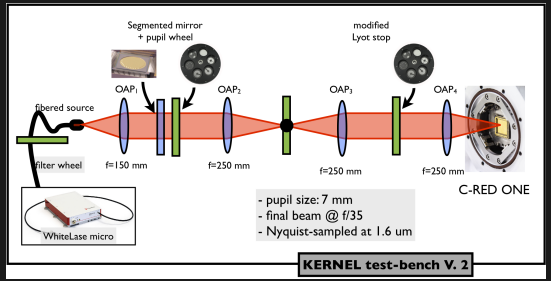
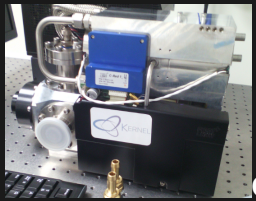
- Optimize scientific yield





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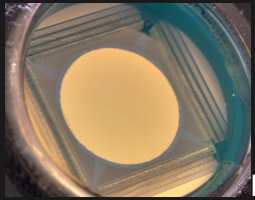
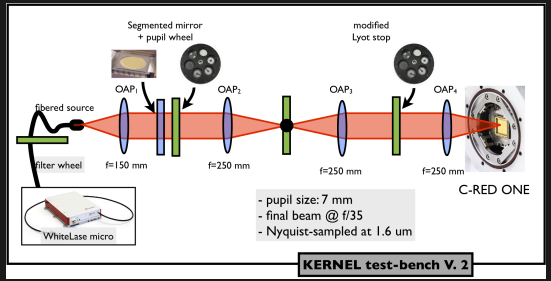


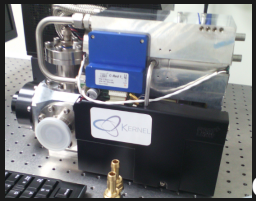
Hex 507

KERNEL: the right tools

A portable instrument:

- Hex 507 segmented DM (BMC)
- C-RED-ONE IR camera (FLI)
- Hunt down systematics
- Optimize scientific yield
- Bypass its limitations





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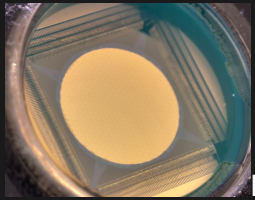
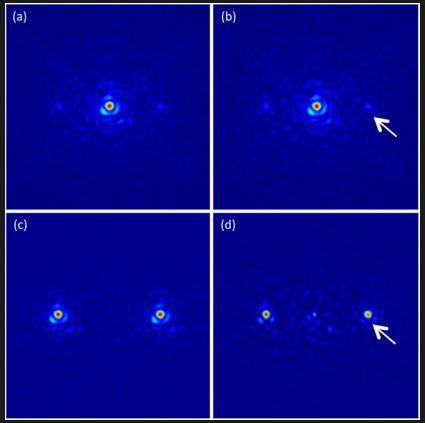


Hex 507

limitation #2: saturation



Working from the focal plane?

- large dynamic range required
- coronagraph destroys the reference

Jovanovic et al, 2016, ApJ, 813, 24

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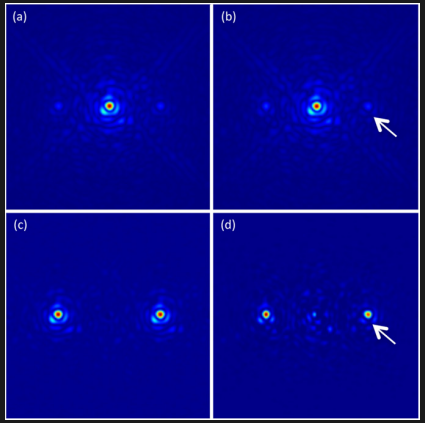

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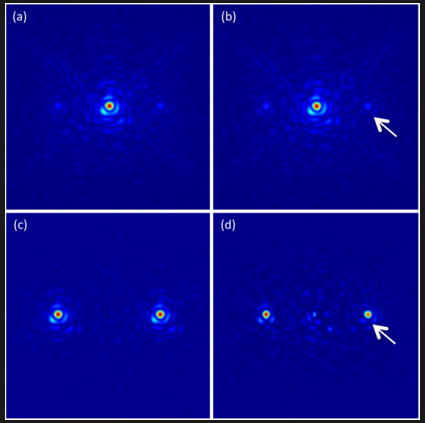


Working from the focal plane?

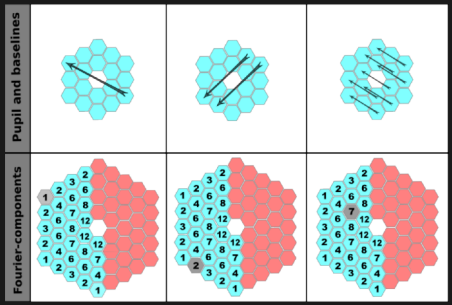
- large dynamic range required
- coronagraph destroys the reference
- cheat to bring the reference back
- use the DM to add incoherent speckles
- get the lost information there
- !! broad-band effects !!

Jovanovic et al, 2016, ApJ, 813, 24

limitation #1: capture range

Learn again from interferometry:

- spectrally dispersed information
- capture range: from $\sim \lambda$ to $\sim R\lambda$
- the KERNEL framework still applies



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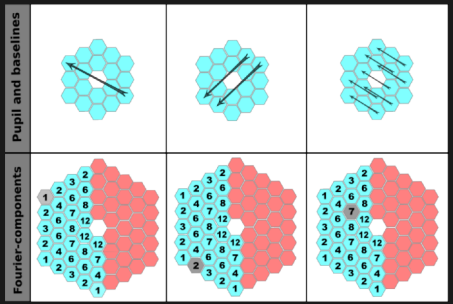
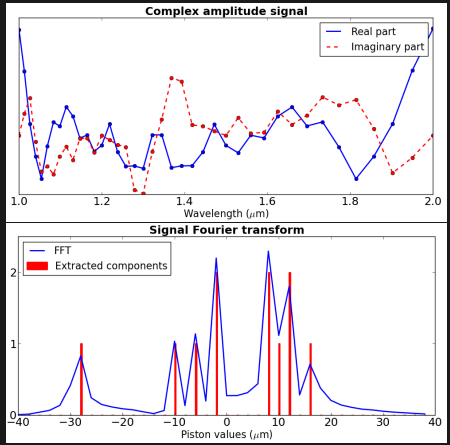
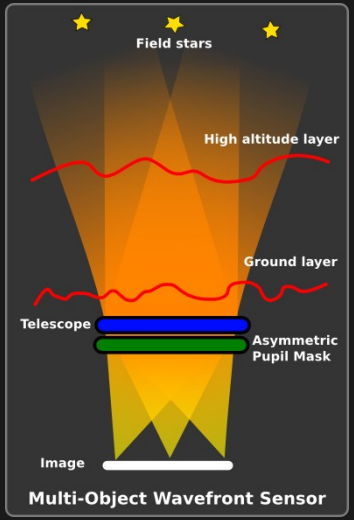




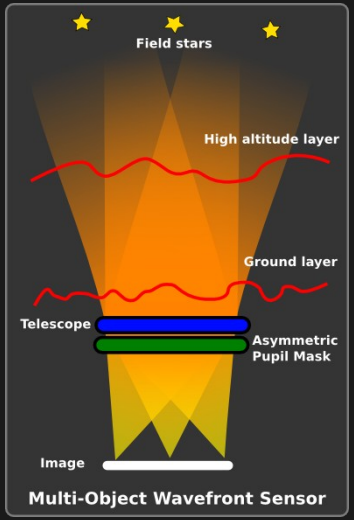
Martinache 2016, SPIE # 9907-36

A different approach to Adaptive Optics?



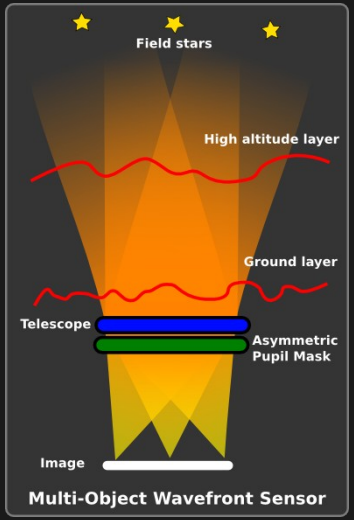
- use the science camera only

A different approach to Adaptive Optics?



- use the science camera only
- WFS $\Leftarrow\Rightarrow$ fringe tracking

A different approach to Adaptive Optics?



- use the science camera only
- WFS $\Longleftrightarrow$ fringe tracking
- no NCP to worry about
- enhanced sensitivity to low-order modes
- do more than just flatten the wavefront
  - create a dark hole in an image
  - optimize injection into a fiber
  - no need to keep a WFS happy

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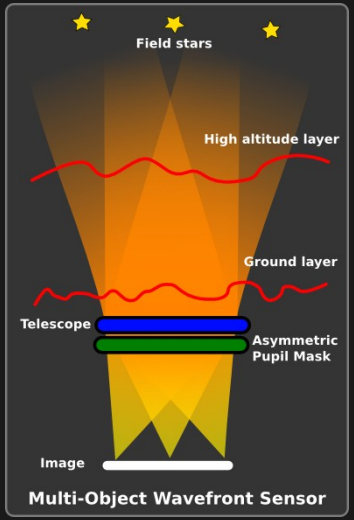

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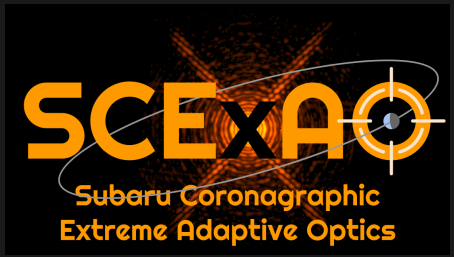
- WFS $\Longleftrightarrow$ fringe tracking
- no NCP to worry about
- enhanced sensitivity to low-order modes
- do more than just flatten the wavefront
  - create a dark hole in an image
  - optimize injection into a fiber
  - no need to keep a WFS happy
- increase capture range: use multi-λ
- scales up nicely as a MOAO system?

Thank you!



Looking for an exciting postdoc? Come and talk to me ASAP!