« DISCO »
Dividing Interferometer for Stars Characterization and Observation
F. Millour, S. Lagarde, P. Berio, Y. Bresson, R. Petrov, L. Abe ...
This talk is about...

- Just an idea...
- Thinking about bringing high-dynamic range imaging to the ELT
- Not yet published, not yet advanced...
Speckle / interférométrie

Image longue pose

Image courte pose

Tavelure : taille typique $\lambda/D$

Tache de seeing $r_0/D$

$r_0 = $ diamètre de Fried

(10cm dans un bon site)
Étoile simple (non résolue)

Étoile résolue

Étoile double

Source : cerimes.fr
Speckle interferometry

- **Historical techniques**
  - « genuine » Speckle
  - Speckle Masking
  - Segment-Tilting

- **New Techniques**
  - Pupil remapping (Perrin / Lacour)
  - Spatio-spectral remapping (This talk)
  - Densification (Labeyrie)
  - Pupil (re-)sampling (Patru)

- **Top results**
  - R136a is not a M>1000M\(_\odot\) star
  - Wolf-Rayet star’s « pinwheels »
  - Protoplanetary disk gap detection
The idea behind speckle interferometry

In a perfect world

Turbulence effect
The idea behind speckle interferometry

In a perfect world

Adaptive optics

Turbulence effect
The idea behind speckle interferometry

In a perfect world

Turbulence effect

Pupil Masking

OTF

1

0

D/λ

f
Perrin et al. 2006 (MNRAS)

In a perfect world

Turbulence effect

Pupil Masking
In a perfect world

Pupil remapping

D/\lambda

f

FIRST Lacour, Huby et al.
DRAGONFLY Tuthill et al.

Perrin et al. 2006 (MNRAS)
Open questions

- How to re-arrange ~1000 pupil (ELTs)?
- How to optimize SNR with many sub-pupils (i.e. many pixels)?
  - Recombine sub-groups of pupils (Dragonfly, FIRST)
  - Play with spectral dimension:
    - build on VEGA/CHARA experience:
      » full-redundant 4 telescope recombiner
      » 3 redundant baselines, coding on OPDs
      » See Mourard et al. 2010 for an explanation
Spatio-spectral remapping

Redundant configuration of the pupil
Non-redundant configuration of OPDs

Allow one to save
\( f \times \text{nbBases} / \text{tbTels} \) pixels
for 18 pupils, \( f=1 \) : save a factor 8

Needs margins on coherence length =
higher spectral resolution

\[ +\delta_1 + \delta_2 + \delta_3 + \delta_4 + \delta_{n-2} + \delta_{n-1} + \delta_n \]
Let’s look at a practice case

- 9 entrance pupils
- 512 spectral channels across JHK (R~600)
- Non-redundant output pupils from Huby et al. 2012
- Needs ~350 pixels for proper fringe sampling
Let’s look at a practice case

- 9 entrance pupils
- 512 spectral channels across JHK (R~600)
- Redundant output pupil with non-redundant OPDs
- Needs ~64 pixels for proper sampling

**FACTOR 5.5 (≈1.8 MAG)**
Other aspects

• Peaks should be separated by ~fringe wandering of the atmosphere, i.e. ±20μm @Paranal
• Maximum OPD should be < Lc / 2

• For 9 sub-pupils, Lc_{min} = 320μm
  => R_{min} = 335 @ 0.95μm

• For 18 sub-pupils, Lc_{min} = 1.7mm
  => R_{min} = 1800 @ 0.95μm
An example setup

This is the FIRST entrance

Small-stroke fibered delay lines

Input pupil

Redundant configuration +ugated wavefront

Spectrograph

Microlens array

Detector

V Groove
An example setup

This is the FIRST entrance

Input pupil

Redundant configuration +ugated wavefront

Detector

Spectrograph

Small-stroke fibered delay lines
What happens when telescope size increases?

- 8m-class telescopes
  - Can be subdivided into 18 ~1m segments
  - Possible to split into sub-groups (FIRST: 2 groups of 9 segments)

- 40m-class telescopes
  - ~1000 1m segments
  - How to recombine all of them?
    - ~100 9-pupils recombiners?
    - Combine groups of segments?
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Optimize ~100 sub-pupils groups?

- 9 sub-pupils
  - 64x512 pixels
- 18 sub-pupils
  - 128x2000 pixels
- 100 sub-pupil
  - 512x40000 pixels detector...
That’s all!