ITHD

News 2017

P. Baudoz

Basé sur les informations reçues !!!!

Plan

- Estimation/Correction : Theory/labs
- Estimation/Correction - tests on sky
- Coronagraph development
- Next instruments
- Post-Processing

Network for “Young” Researcher in Instrumentation for Astronomy

NYRIA – Workshop
Du 16 au 19 Mai 2017
Observatoire de Meudon

Restricted to ground-based Vis/IR instrumentation:
-Institute collaborations
-Network
-Presentation on state-of-the art methods in instru
-Discussion about the future of instrumentation
…

Initiative after Summer School in Chile 2014 (18 people)
-> Meeting at MPIA, Heidelberg in 2015 (9 people)
-> Meeting at CfIA, Durham in 2016 (10 people incl. 4 new)
-> Meeting at LESIA, Meudon in 2017, **27 attendees**, including 20 new to the network:
10 postdoc, 15 PhD, 2 MSc
10 French, 8 German, 4 Dutch, 3 U.K, 1 USA, 1 Belgian
6 girls
7 ASHRA (Fr)

Our blog !

Main astrophysics applications: Exoplanet imaging, RV, transit, spectroscopy
Main instruments involved: E-ELT and ELTs
Main domains presented: High contrast imaging, astrophotonics, interferometry
Main technics presented: fibers, polarization, image processing, detectors

Discussions' topic: Astrophysics vs instrumentation, risks vs innovation, timeline vs moneys
Big vs small projects, synergy ESO/industry/small labs/famous institutes

Starting time	Duration	Tuesday	Wednesday	Thursday	Friday
09:00	00:15	Introduction NYRIA	Talk 8	Talk 18	**Discussion:** Building an instrument today
09:15	00:15	Introduction PARIS	Talk 9	Talk 19	
09:30	00:15	Introduction workshop 2017	Talk 10	Talk 20	
09:45	00:15	Talk 1	Talk 11	Talk 21	
10:00	00:15	Talk 2	Talk 12	Talk 22	
10:15	00:15	Talk 3	Talk 13	Talk 23	
10:30	00:15	Buffer	Buffer	Buffer	
10:45	00:30	*Coffee break*	*Coffee break*	*Coffee break*	*Coffee break*
11:00					
11:15	00:15	Buffer	Buffer	Buffer	Preparing for NYRIA 2018
11:30	00:15	Talk 4	Talk 14	Talk 24	
11:45	00:15	Talk 5	Talk 15	Talk 25	
12:00	00:15	Talk 6	Talk 16	Talk 26	**End of meeting**
12:15	00:15	Talk 7	Talk 17	Summary of talks	
12:30	01:30	*Lunch*	*Lunch*	*Lunch*	
13:00					
13:30					
14:00	02:00	**Lecture:** P. Léna	**Lab visits:** Meudon Observatory	**Cultural visit:** Observatory of Paris	
15:00					
16:00	01:00	*Coffee break*			
17:00	01:00	Introductions of attendees			
18:00			**Group picture**		
19:00		*Dinner*	*Dinner*	*Workshop dinner*	

Legend
Talks
Activities
Break

Bibliography ADS 06/2016=>06/2017

Estimation/Correction : Theory/labs (Referee paper only, French lab involved)

- Herscovici-Schiller, O., Mugnier, L. M., & Sauvage, J.-F., « An analytic expression for coronagraphic imaging through turbulence. Application to on-sky coronagraphic phase diversity », 2017, MNRAS, 467, L105

Presentation O. Herscovici-Schiller

- Beaulieu, M., et al., « High-contrast imaging at small separation: impact of the optical configuration of two deformable mirrors on dark holes », 2017, MNRAS, 469, 218

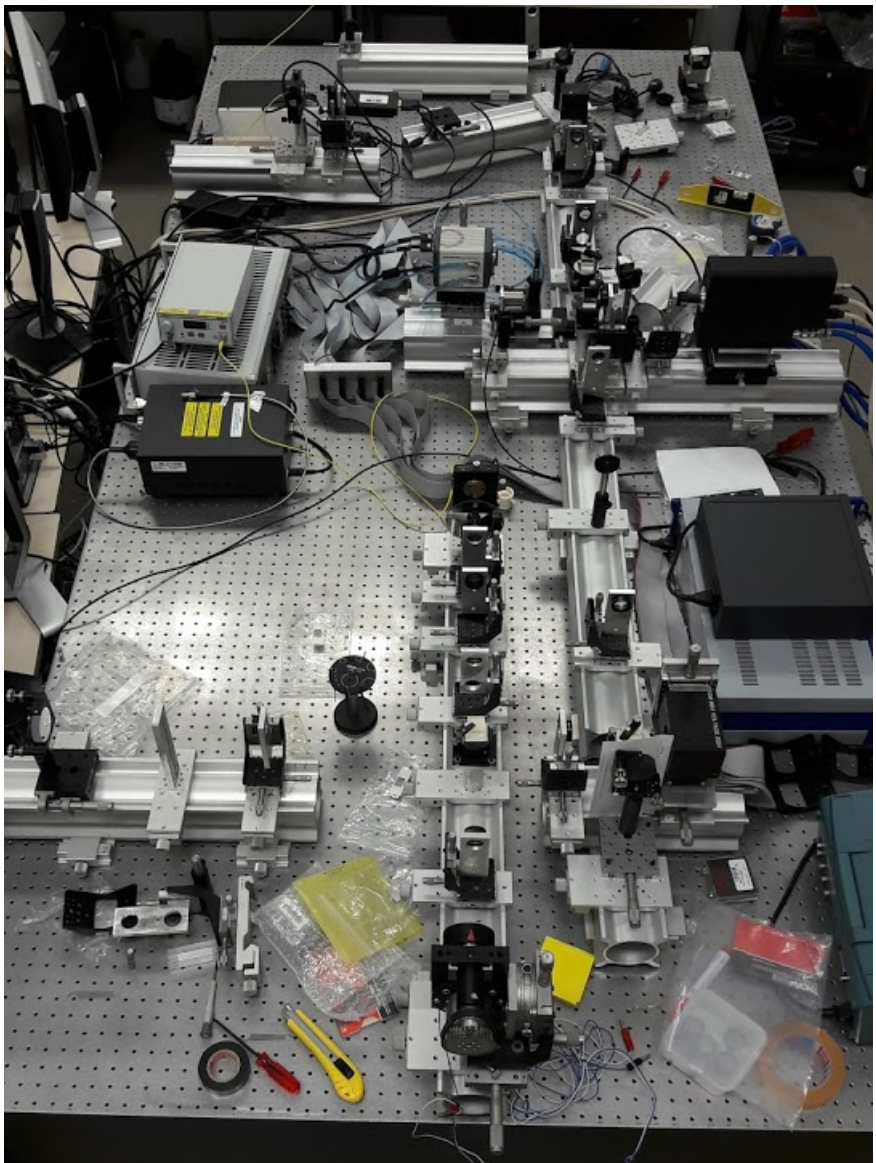
Presentation OCA ?

- Janin-Potiron, P., et al., « The self-coherent camera as a focal plane fine phasing sensor », 2016, A&A, 592, A110

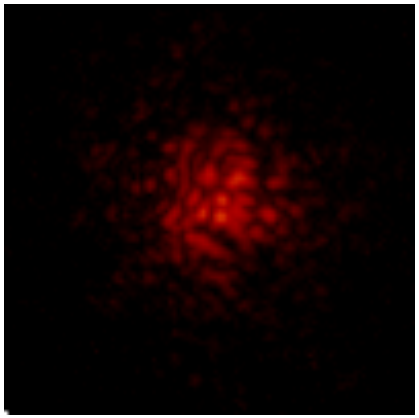
- Meanwhile elsewhere :
  - Wilby et al. « The coronagraphic Modal Wavefront Sensor: a hybrid focal-plane sensor for the high-contrast imaging of circumstellar environments », 2016, A&A,

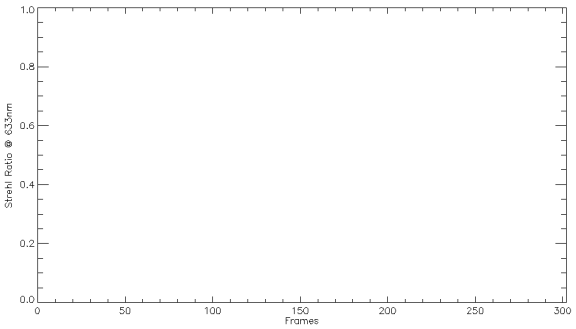
L’analyseur à pyramide au LAM

- Développement d’un banc d’OA dédié à la Pyramide depuis 4 ans
  - Caractérisation de l’analyseur
  - Premiers résultats en 2016
  - Plate-forme de test pour HARMONI
- Configuration de la pyramide:
  - 50x50 pixels pupil image
  - Compatible CRED 2
  - Low Order DM, compatible SLM
- Manpower
  - C. Bond, post-doc
  - O. Fauvarque, PhD
  - Equipe OA

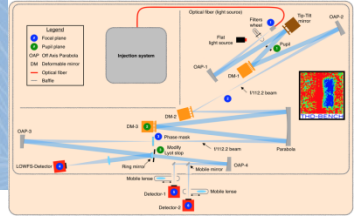


Boucle fermée LOOPs

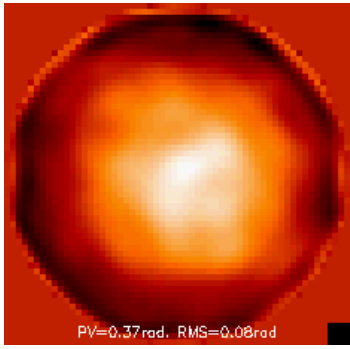


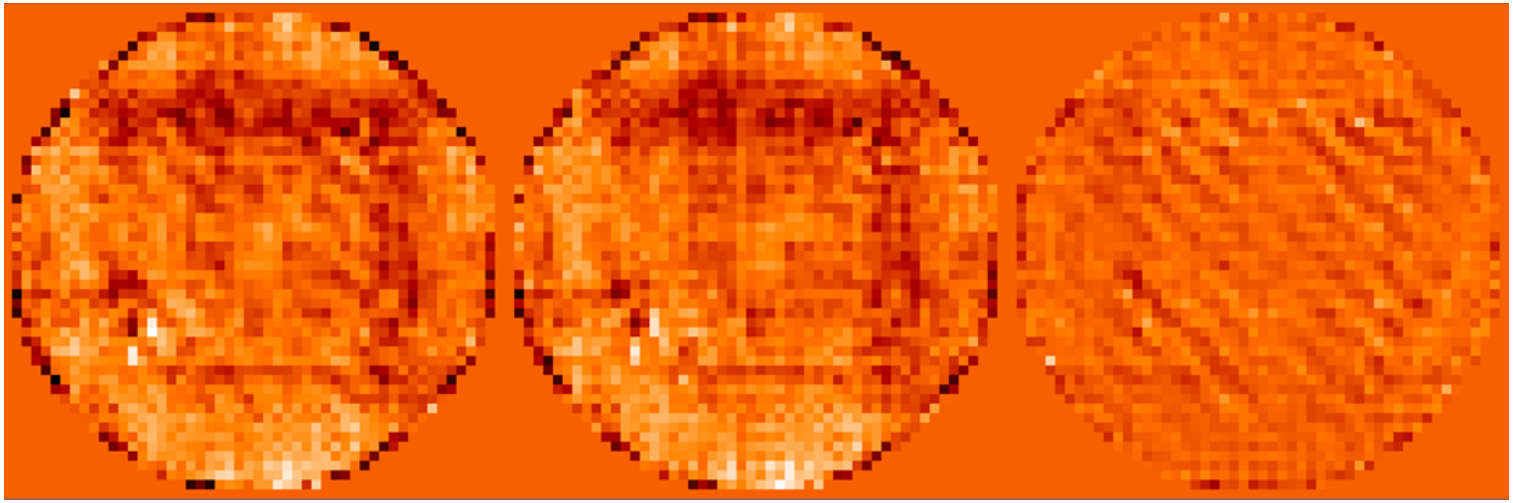


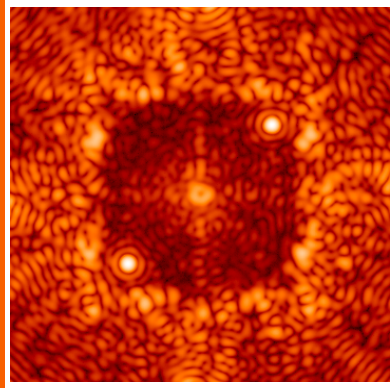
1ère démonstration expérimentale de “COFFEE complexe”, sur le banc THD



- Recherche aberrations de phase *et d'amplitude* pour très haut contraste
- Collaboration LESIA, financement R&T CNES
- Résultats :
  - Étalonnage fin de ce qu’introduit vraiment le DM Boston
  - Mesure d’aberration d’amplitude sinus, 11 cycles/pupille à 45°:







Avec défaut d’amplitude / sans défaut / différence ;) !

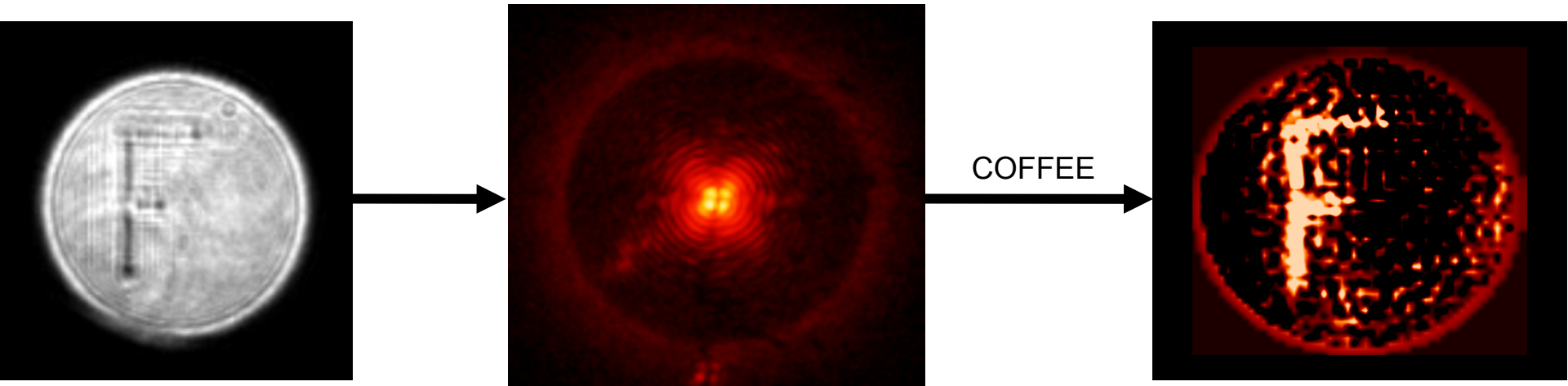
- Perspectives :
  - dépouillement nouvelle campagne de mesure (vs SCC)
  - correction par dark-hole non linéaire : à venir (R&T en cours)

ONERA THE FRENCH AEROSPACE LAB

COFFEE On-Sky measurement of aberrations : MITHIC lab demo

COFFEE: Coronagraphic phase diversity.

- Focal-plane wave-front sensor: uses scientific camera, so no NCPA
- Goal: use directly on-sky to measure / correct quasi-static aberrations during observations
- Need for a model of image formation → Development of a simple analytic expression for the long-exposure coronagraphic PSF (published in MNRAS[1])
- Experimental validation on MITHIC bench at LAM, with an XAO turbulent module generating SPHERE-like residuals



11nmRMS phase of a « F » pattern

focal-plane image (experimental image)

Phase reconstructed by COFFEE: 13.5nmRMS

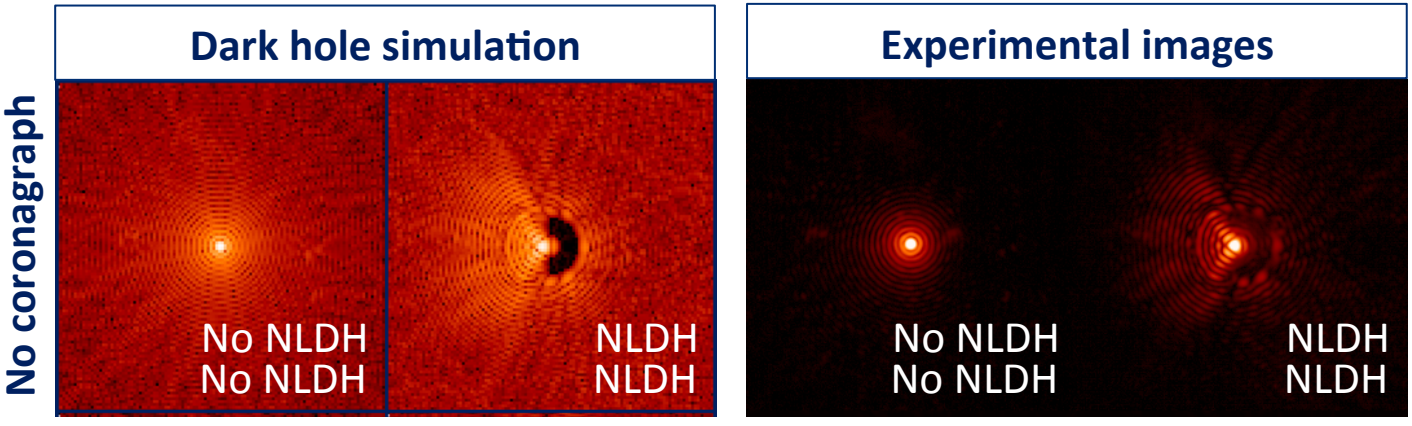
1 Olivier Herscovici-Schiller, Laurent M. Mugnier, Jean-François Sauvage; *An analytic expression for coronagraphic imaging through turbulence. Application to on-sky coronagraphic phase diversity*. Mon Not R Astron Soc Lett 2017; 467 (1): L105-L109. doi: 10.1093/mnrasl/slx009

NON-LINEAR DARK HOLE : Lab validation on MITHIC
(O. Herscovici / L. Leboulleux)

- GOAL : validate the Non Linear Dark Hole technique
  - Only needs Influence Functions approximative knowledge
    - **=> Valid even with dead actuators !**
  - **No iterative process** : direct application of dark hole in 1 shot
  - Needs WFS : given by COFFEE
- MITHIC configuration
  - No coronagraph
  - Deformable mirror : SLM modelizing a **SPHERE 41x41 DM**
- Result :
  - Validated on **Non-coronagraphic** case
  - Result seems in accordance with simulation
- Perspectives :
  - To be continued with a RR coronagraph (or other less sensitive to TT ?)
  - To be tested on SPHERE

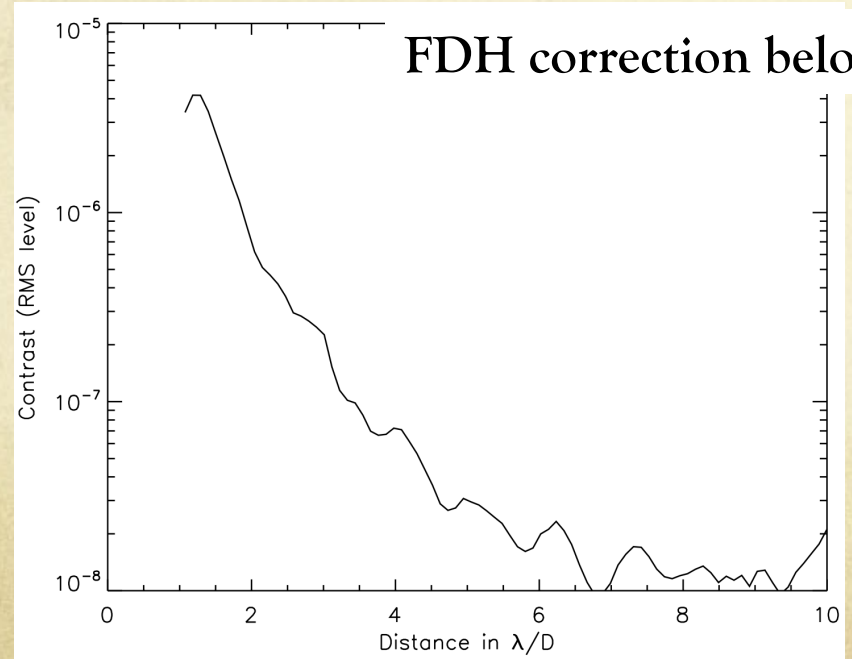
Tools	
R&Roddier	Coronagraph
Science camera	Sensor
COFFEE	Estimator
NLDH	Controller

Dark hole
Semi-donut

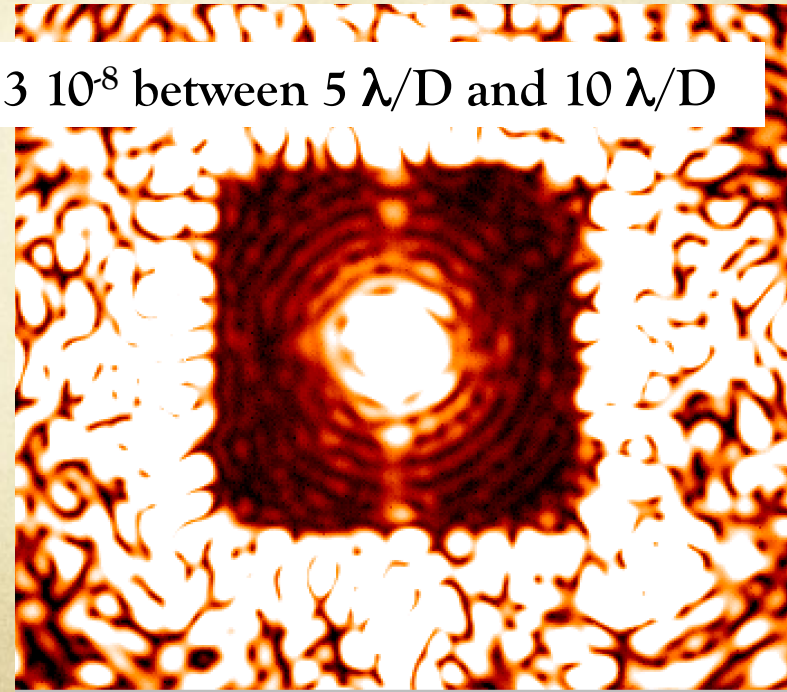


Multi-DM amplitude correction

- **Problem:** Amplitude aberrations of the instrument limits the efficiency of coronagraphic instruments
- **Purpose:** To use multiple DMs to correct amplitude aberrations
- **Current activities (LESIA):**
  - Theoretical and algorithm aspects (collab with Nice Obs.)
  - Experimental tests on THD2



FDH correction below 3 10^{-8} between 5 λ/D and 10 λ/D



Bibliography ADS 06/2016=>06/2017

Estimation/Correction - tests on sky (Referee paper only, French lab involved)

- Huby, E., et al., « On-sky performance of the QACITS pointing control technique with the Keck/NIRC2 vortex coronagraph », 2017, A&A, 600, A46

Presentation E. Huby

- Serabyn, E., et al., « The W. M. Keck Observatory Infrared Vortex Coronagraph and a First Image of HIP 79124 B », 2017, AJ, 153, 43
- N'Diaye, M., et al., « Calibration of quasi-static aberrations in exoplanet direct-imaging instruments with a Zernike phase-mask sensor. II. Concept validation with ZELDA on VLT/SPHERE », 2016, A&A, 592, A79
- Martinache, F., Jovanovic, N., & Guyon, O., « Closed-loop focal plane wavefront control with the SCExAO instrument », 2016, A&A, 593, A33

- **Meanwhile elsewhere :**

- Otten et al. 2017, « On-sky performance analysis of the vector apodizing phase pate coronagraph on MAGAO/CLIO2 »

ZELDA – On Sky measurement run

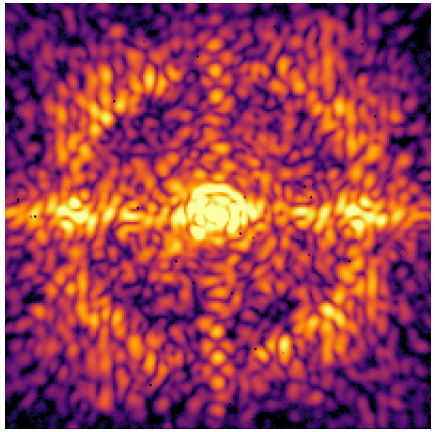
- **2015**
  Validation de la compensation des NCPA en interne (N'Diaye et al. 2016)
  - gain d'un facteur ~10 à 0.2" sur source interne.

- **2016**
  Identification de turbulence interne avec ZELDA (±10 nm PV)

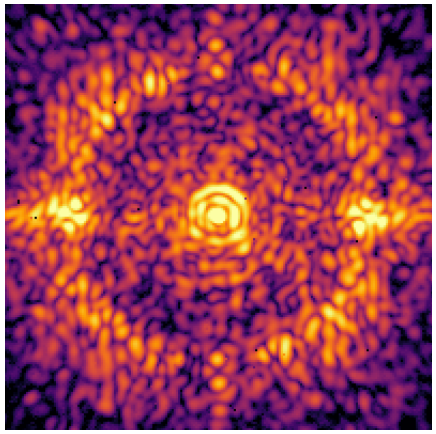
- **mars 2017**
  - implémentation **d'un template de calibration** sur SPHERE à Paranal avec compensation iterative des NCPA
  - premiers tests sur le ciel pas très concluants
  - plusieurs hypothèse en cours d'investigation (changement du spatial filter, erreurs d'amplitude du M1, beamshift chromatique, erreurs d'amplitude apodiseur dans la mesure ZELDA)

- **Perspectives 2017**
  - mise en place d'un monitoring des NCPA avec le template
  - sauvegarde des fichiers dans l'archive pour suivi régulier

- **Perspectives 2018**
  - compréhension des limitations actuelles
  - implémentation de la calibration ZELDA en début de nuit



SPHERE internal



After ZELDA + NCPA compensation

Low Wind Effect

- Strong limitation to SPHERE performance

- 2015 :
  - Identification of origin (heat exchange around M2)
  - Development of focal-plane measurement method
  - Validation on SPHERE : measure and compensation of LWE as a classical NCPA

- 2016 :
  - Validation of LWE measurement on MITHIC
    - Masen Lamb invited researcher, paper accepted (JATIS)
    - Michael Wilby, paper ongoing

- 2017 :
  - Validation of LWE compensation on Subaru Telescope (MNDiaye / FMartinache)
  - ESO modifies the cover of M2 spiders to reduce the effect
  - In case of failure (or partial recovery), installation on SPHERE of the focal-plane method

Bibliography ADS 06/2016=>06/2017

Coronagraph development (Referee paper, Fr. lab involved)

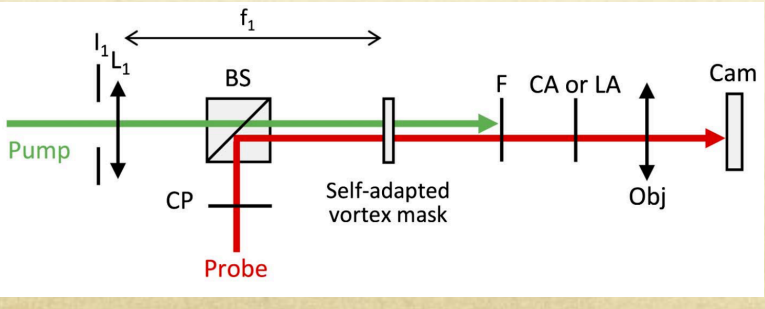
- Aleksanyan et al. , « Multiple-Star System Adaptive Vortex Coronagraphy Using a Liquid Crystal Light Valve », 2017, Phys Rev. L, 118
- Aleksanyan, A., & Brasselet, E., « Self-eclipsing: alignment-free vortex coronagraphy », 2017, OptL, 42, 1237
- Aleksanyan, A., & Brasselet, E., « Vortex coronagraphy from self-engineered liquid crystal spin-orbit masks », 2016, OptL, 41, 5234
- Vargas Catalan, E., et al., « Optimizing the subwavelength grating of L-band annular groove phase masks for high coronagraphic performance », 2016, A&A, 595, A127
- Delorme, J. R., et al., « Laboratory validation of the dual-zone phase mask coronagraph in broadband light at the high-contrast imaging THD testbed », 2016, A&A, 592, A119
- Fogarty et al., « Polynomials apodizers for centrally obscured vortex coronagraph », ApJ, 2017

Meanwhile elsewhere :

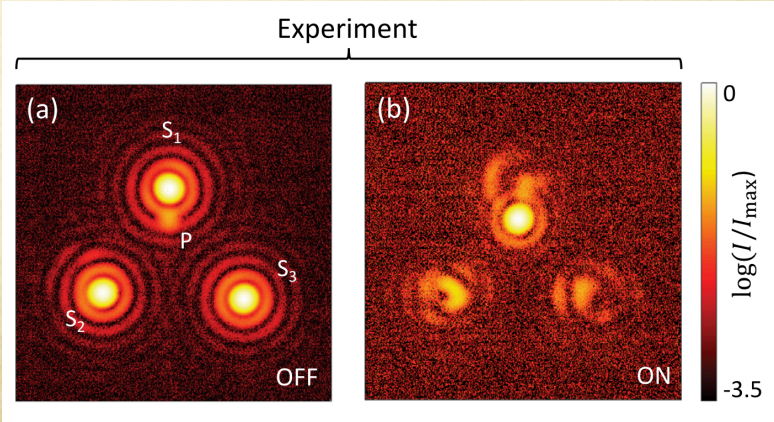
- Liu et al. 2017, « Design and experimental test of an optical vortex coronagraph »

New coronagraph solution

- **Problem :** Coronagraphs still need development to reach the requirements for low-mass planet detection. or to be used with multiple stars
- **Objective:** New solution studied using spin-orbitl angular momentum conversion. Allows extinction of multiple stars to search for planets in these systems
- **Current activities (LOMA, Bordeaux):**
  - Liquid crystal spin-orbit masks
  - Absorptive material spin-orbit masks
  - Multi-star coronagraph using liquid crystal light valve
  - Tests planned on the THD2 bench (collab LOMA-LESIA)



Aleksanyan et al. 2016, 2107a, 2017b



Highly achromatic coronagraph 1/3

- **Problem :** Small Inner Working Angle (IWA), highly achromatic (Broadband spectroscopy) and highly efficient coronagraphs are mandatory for future space instruments and ground-based instruments too

- **Objective:** Development of highly achromatic coronographic components based on phase mask coronagraphy

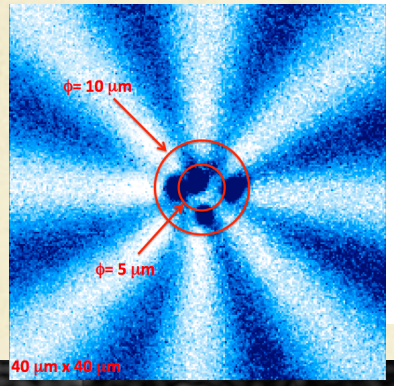
- **Current activities (LESIA):**

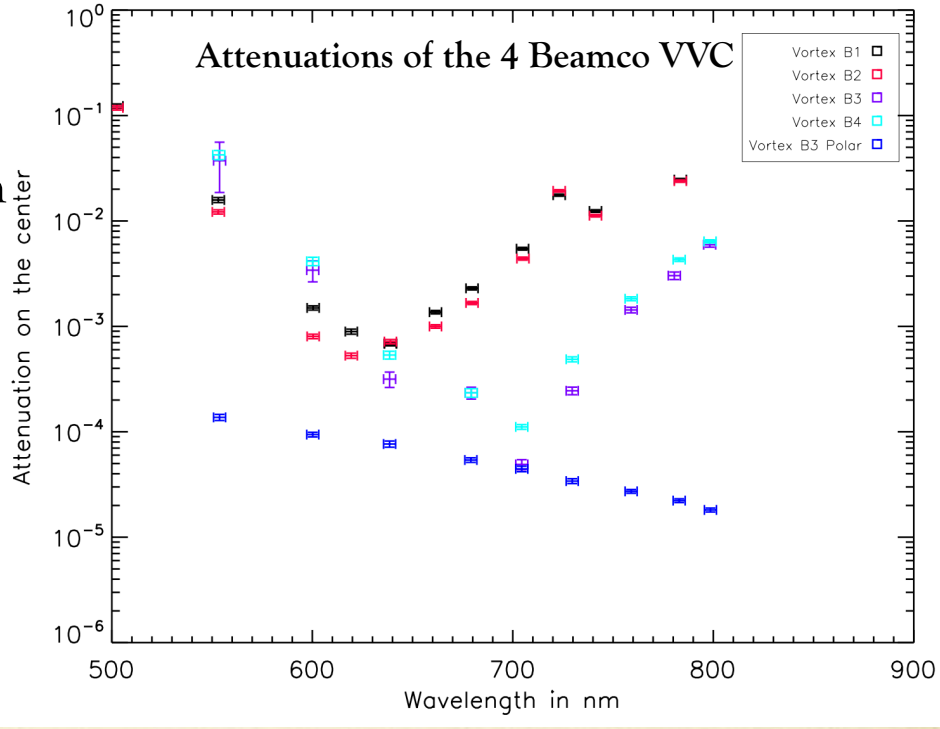
1. **Liquid Crystal Polymer Technology (4 components) :**
   - Tests onTHD2 of VVC (fabricated by Beamco, USA)
2. **Photonic layers technology (2 components) :**
   - Tests on THD2 of VVC and Eight Octant Phase Mask (collaboration with NAOJ and Hokkaido Univ.)
3. **Achromatization of the phase using spatial distribution (2 components)**
   - Theoretical work in collaboration with Shanghai Univ.
   - Development of components in Paris Obs. (Collab GEPI/Obs. Paris)
   - Tests on THD2

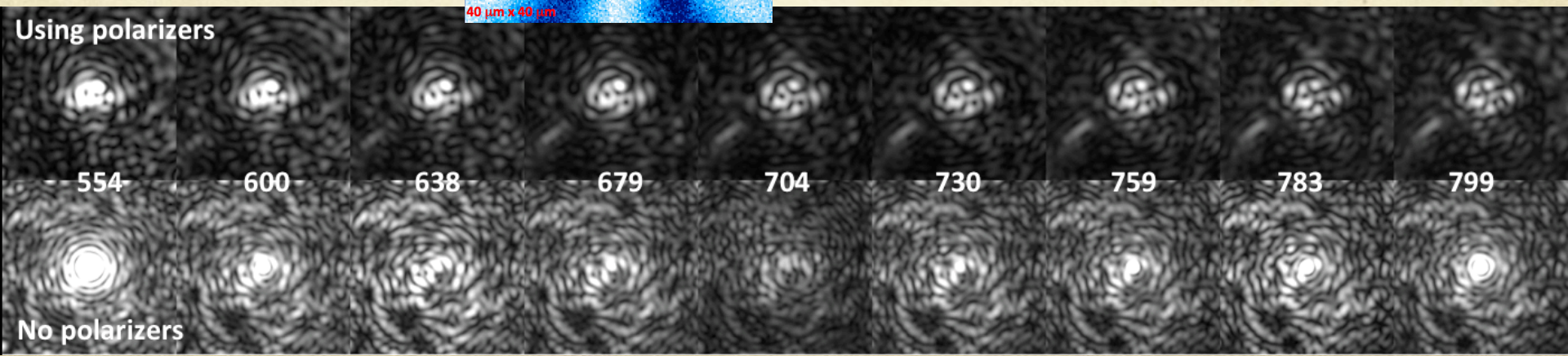
Highly achromatic coronagraph 2/3

4 components based on Liquid Crystal Techology (Beamco) tested on THD2

- Specs: VVC charge 4 - 600-800nm with achromaticity better than 10^{-5}
- Technology not yet ready for very high contrast
- Expensive
- Requires polarizers





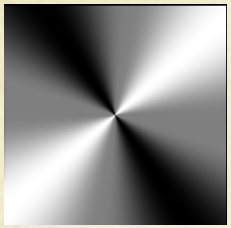


Highly achromatic coronagraph 3/3

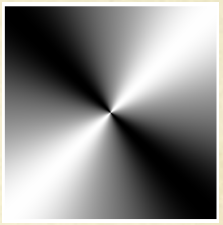
Achromatization of the phase using spatial distribution

Theoretical development (in collaboration with Shanghai university)

Mask designed by Shanghai Univ :



Mask designed by LESIA :

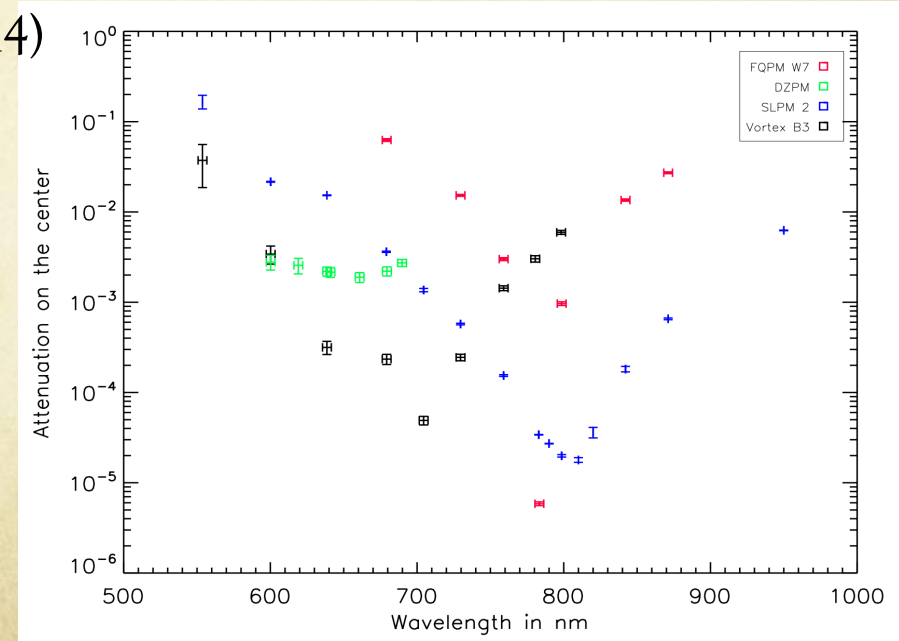


Experimental development (in collaboration with GEPI/Obs. Paris)

- Achromatization of the Four Quadrant Phase Mask (FQPM)=> Six Layers Phase Mask (SLPM, Hou et al. 2014)

Comparison of 4 types of coronagraph tested on THD2 :

- FQPM
- DZPM
- VVC (no polarizers)
- SLPM (**Best achromatic solution tested so far over 100nm**)



Next instruments- Post-processing

- E-ELT : MICADO - HARMONI
- LBT : SHARK-NIR
- Post-processing

Meanwhile elsewhere :

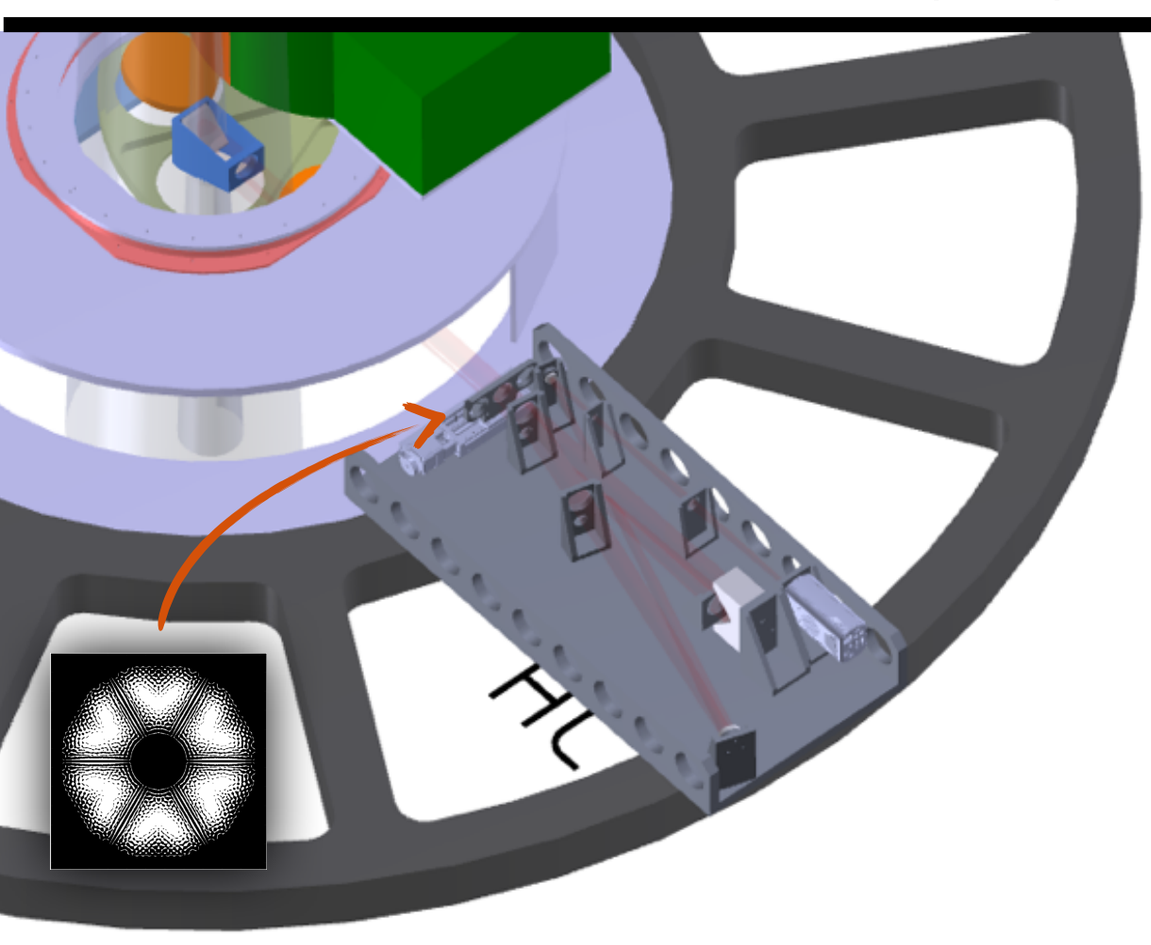
- Wang et al. 2017, « Observing exoplanets with high dispersion coronagraphy. I The scientific potential of current and next-generation large ground and spece telescopes »
- Mawet et al. 2017, « Observing exoplanets with high dispersion coronagraphy. II. Demonstration of an active single-mode fiber injection unit »

1 - HARMONI High-Contrast Mode

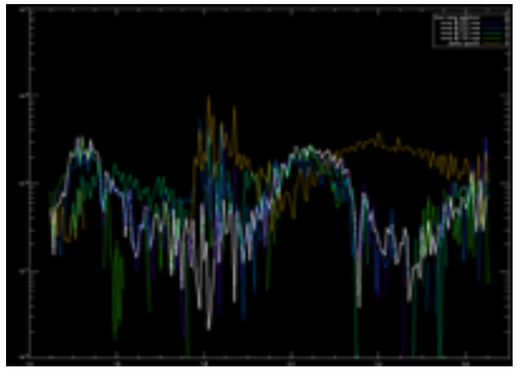
A. Carlotti, C. Vérinaud, K. Dohlen, P. Rabou, Y. Magnard, F. Hénault, A. Vigan,
T. Fusco, D. Mouillet, M. Bonnefoy, P. Delorme

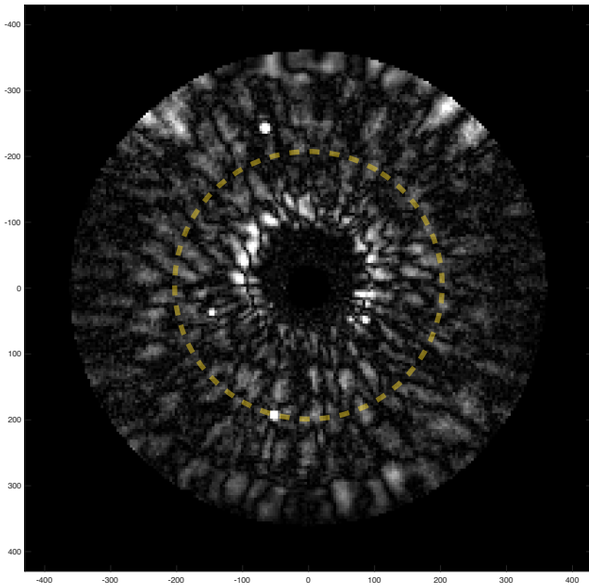
Goal: 10^{-6} contrast at 0.2”, at 2.2 µm, with JQ1 seeing (0.48”).

- optomechanical design w/ on/off HC mode, ZELDA WFS at 1.25 µm.
- error budget for quasi-static speckles to limit contrast at 10^{-5}.
- data produced w/ end-to-end model ; first post-processing results estimate ~10^{-6} contrast at 0.1-0.2” w/ JQ1 seeing.
- cost estimate: 140 k€ (HC) + 50 k€ (HARMONI optics, TBC)



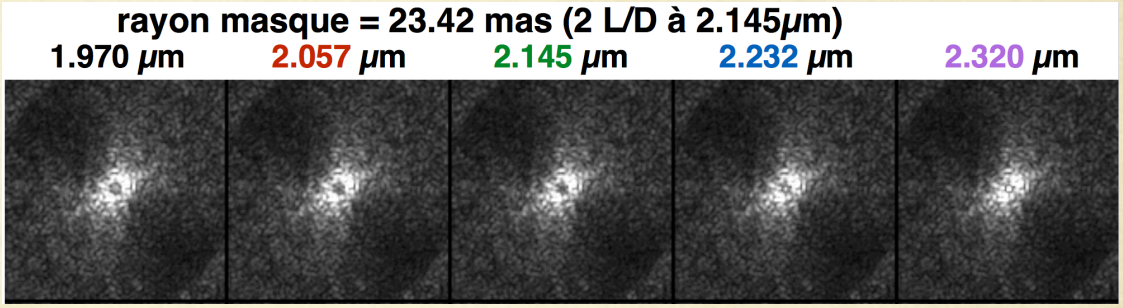
- 10^{-6} planets at 0.1-0.25”
  z~45°, H=6 star, 2h obs (HA=±1)
- Simulations w/ βPic & 51Eri spectrum
- sADI, SDI & Andromeda used to extract spectrum.



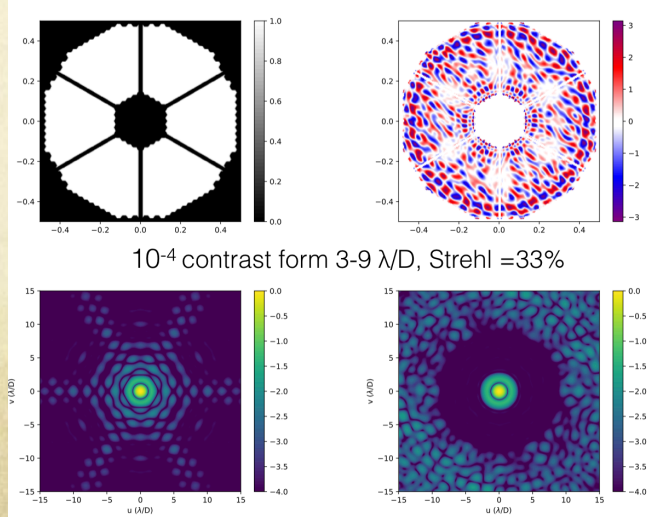


MICADO

- **Design**
  - Close to finalization of Lyot coronagraph design (focal mask diameter, Filtering in Lyot plane)



  - Addition of vector APP masks proposed by Leiden



- **SRR in April 2017**
  - OK

2 - LBT/SHARK-NIR coronagraphs

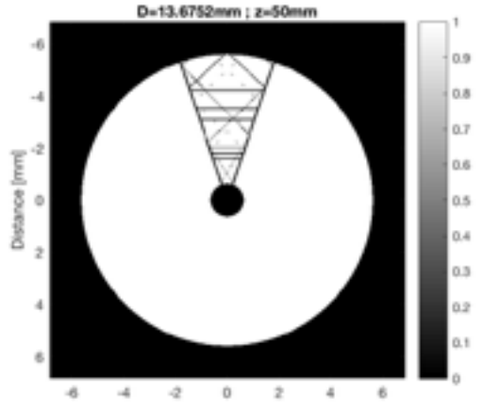
A. Carlotti, C. Vérinaud, J. Farinato, D. Vassalo, E. Carolo, D. Greggio

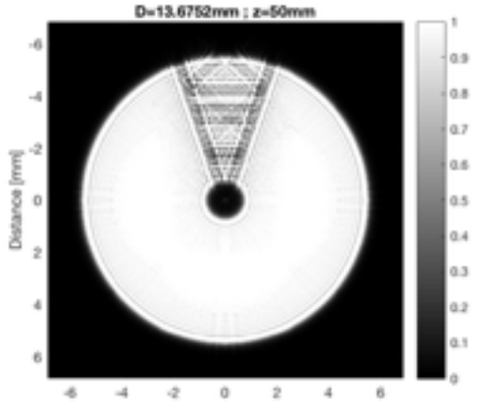
Coronagraphs to observe 10^{-5}-10^{-6} planets at ~0.1-0.15” in J & H.

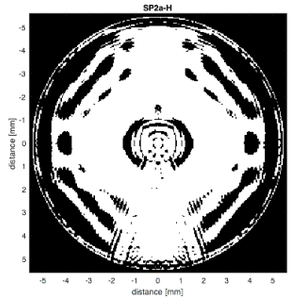
Two main concepts: Shaped pupils & fully optimized APLC

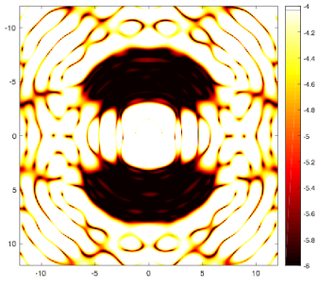
Various constraints make it a difficult problem: 50mm distance between pupil plane and apodizers, dispersion in Lyot plane…

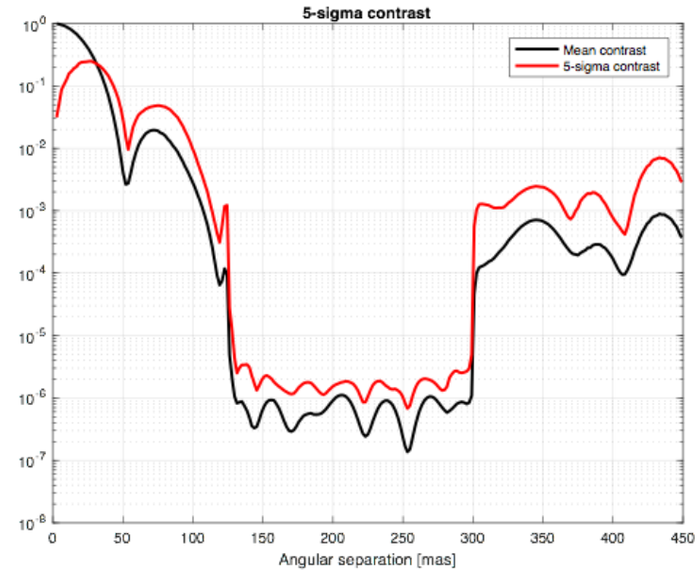
Shaped pupils for non-conjugated plane:





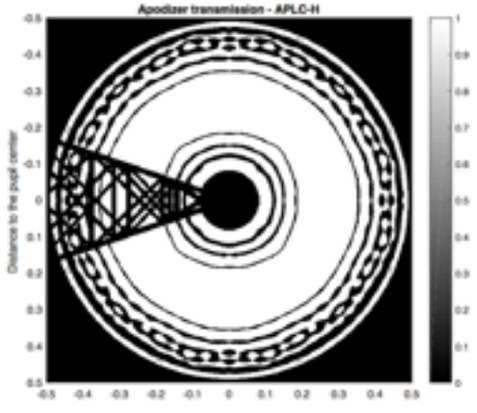




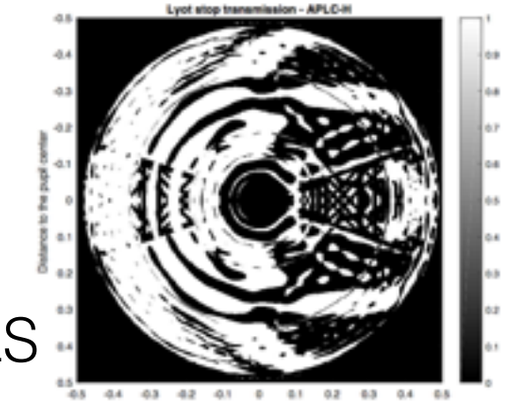


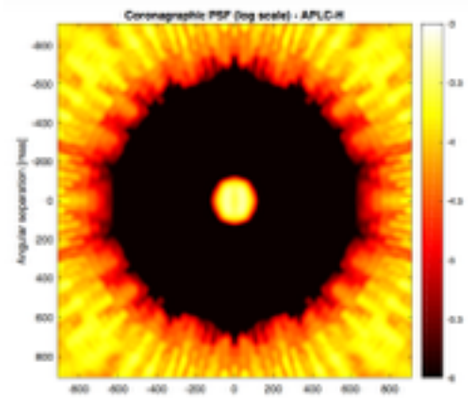
Fully optimized APLC:

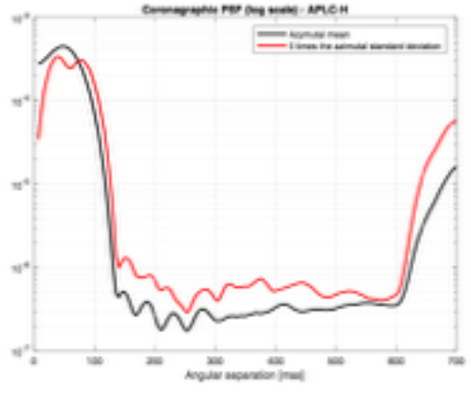
Apodizer



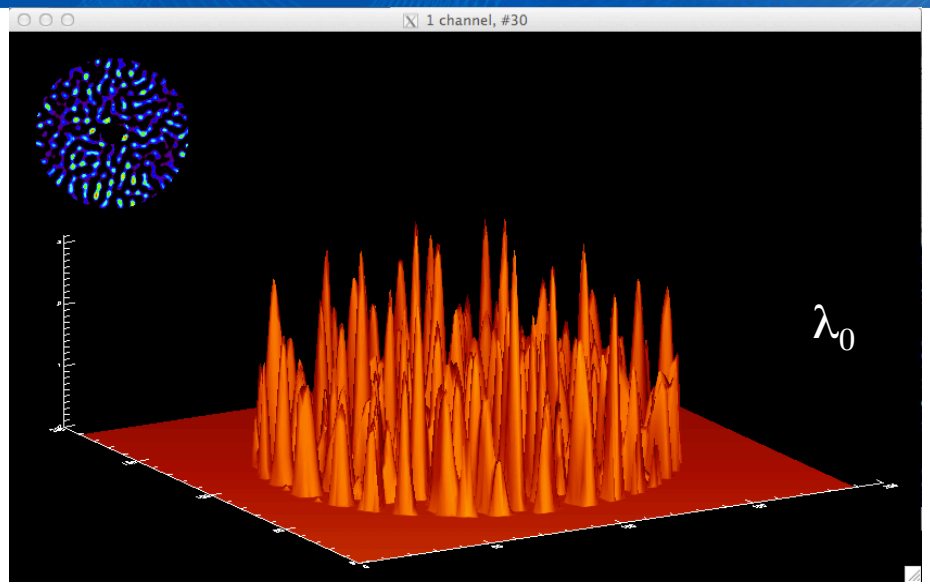
LS

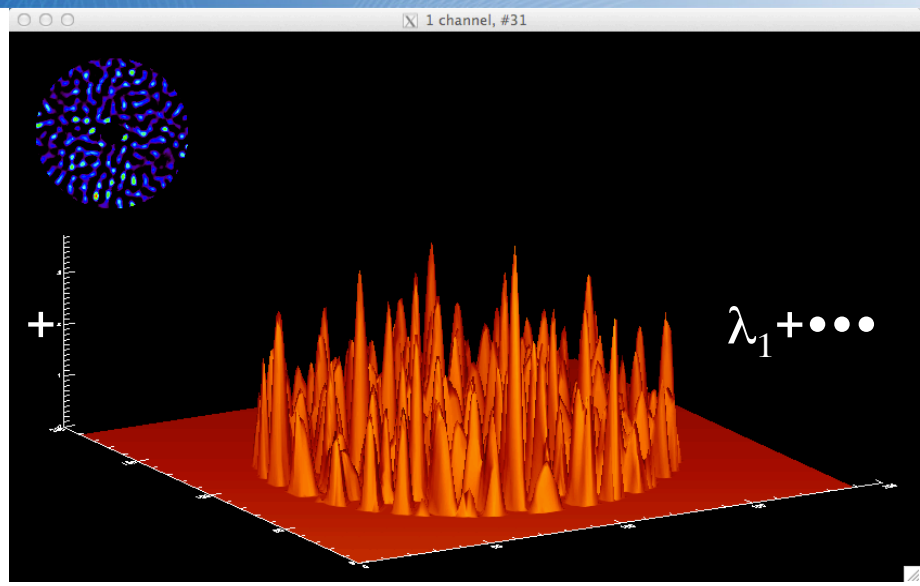




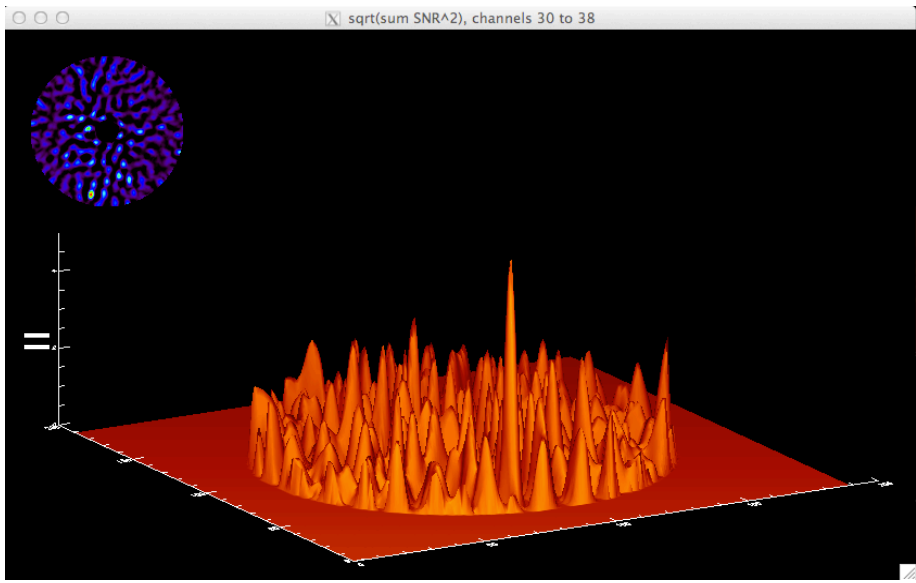


Détection multispectrale sur SPHERE/IFS avec ANDROMEDA





- **ANDROMEDA** : ADI + SDI
  (exploite rotation champ + speckle(λ))
- **+ détection optimale** [Thiébaut et al 2016]
  (exploite position planète identique ∀λ)
- => **détection optimale multi-λ**,
  => précision astrométrique ++ [Samland 2017].
  => amélioration estimation spectre
- au-delà de l'approximation 1er ordre :
  modélisation speckles via aberrations.



carte de SNR multispectral
= sqrt(somme carrés SNRs seuillés)

ONERA
THE FRENCH AEROSPACE LAB

NEWS CRAL - Activités de R&D amont en ITHD

- Science des données (développement de nouvelles méthodes pour traitement des données ITHD) ITHD)
  - **Détection optimale à partir des données multi-variées des** exo-planètes et des disques circumstellaires : SPHERE (VLT), EPICS (ELT), projet DETECTION (pluridisciplinaire CNRS)
    - Méthode PEX: N. Devaney, E. Thiébaut, M. Langlois
    - Méthode statistique basée sur les patches (O. Flasseur, L. Denis, E. Thiébaut, M. Langlois)
    - Approche inverse + PEX: Extraction optimale des spectres en LSS (T. Wanner, Éric Thiébaut, M. Langlois)
    - Approche inverse pour la Polarimétrie (IRDIS DPI – L/ Denneulin, M. Langlois, E. Thiébaut)
  - **Autocalibration**
    - Approche inverse appliquée à la Polarimétrie (IRDIS DPI) - Calibration de la polarisation instrumentale à partir des données – imagerie des disques circumstellaires (IRDIS DPI – L/ Denneulin, M. Langlois, E. Thiébaut)
- *Collaborations: Université de saint- Etienne (LHC), Université de Galway, SPHERE consortium, ONERA,*

Keplerian-Stacker

- **Description:** Détecter des planètes cachées (SNR<1) qui se déplacent dans des images coronographiques prises sur plusieurs mois-années.

- **Statut:** Démonstration réussie avec un algorithmes de minimisation en introduisant de fausses planètes à SNR<1 dans un groupe d'images simulées (SPHERE-IRDIS)

  Le Coroller et al. 2015, OHP2015; Nowak, et al. 2016, A&A, soumis

- **Demande ANR en cours sur le sujet**

- **Calendrier attendu:**
  - 2016: Introduire de fausses planètes (SNR<1) dans des images d'archive (NaCo…) et les retrouver avec K-Stacker (adaptation de l'algorithme aux vrais données)
  - 2017: Recherche de planètes dans des images d'archives NaCo, Keck, SPHERE, etc.
  - 2018 . Demande de temps (SPHERE) pour rechercher de nouvelles planètes autours d'étoiles « prometteuses » (Jeunes, brillantes, planètes déjà trouvées ou suspicion…)