DIRECT DETECTION OF EXOPLANETS USING TUNABLE KERNEL-NULLING

Vincent Foriel[1,*], Frantz Martinache[1], David Mary[1]

[1] Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, France

[*] vincent.foriel@gmail.com

In a nutshell

This thesis aim to enhance nulling interferometry for exoplanet detection using a four-telescope architecture named Kernel-Nuller. By integrating 14 active phase shifters, we aim to mitigate phase aberrations caused by manufacturing defects. An algorithm is developed to optimize device performance, validated through simulations and lab experiments. A second phase consist in analyzing intensity distributions produced by Kernel-Nuller and applying statistical tests and machine learning to extract science information. This poster present the preliminary results.

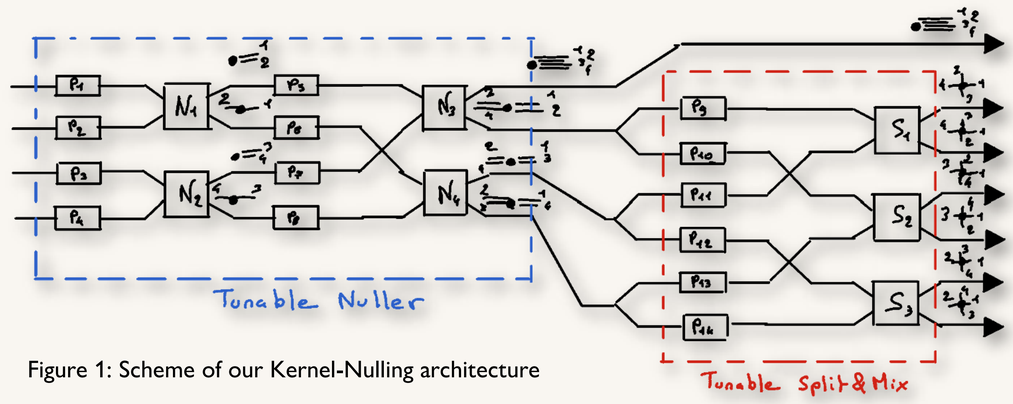


Figure 1: Scheme of our Kernel-Nulling architecture

Nulling interferometry

On the VLTI

This technique consist in taking advantage of the angular separation and the coherence properties of the light to destroy the star light and combine the planet light in the same process.

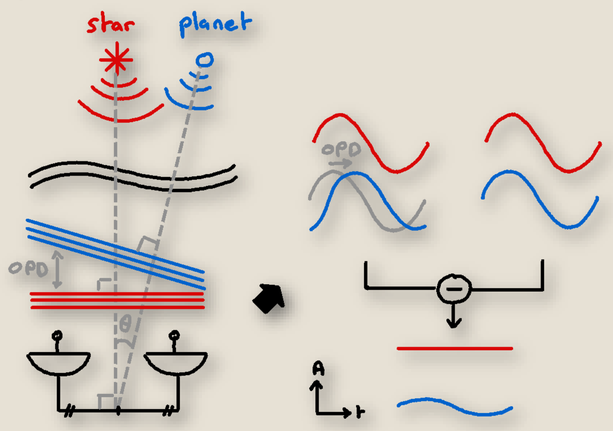


Figure 2: Concept of nulling interferometry

Our approach enhance this principle by introducing « Kernels » which combine the light from 3 telescopes or more in order to be less sensitive to low order phase aberations and asymetrize the output to better constrain the planet position.

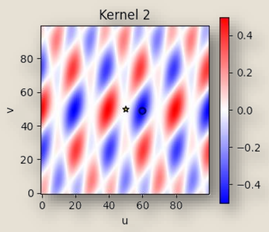


Figure 3: Transmission map of one of the Kernels obtained using the 4 telescopes of the VLTI. The transmission zones and blind bands are directly derived from the UT position. By rotating the baseline, we can get a modulated signal from which we can precisely constrain the planet position.

Thermo-optic phase shifter

Coming from telecom technologies, the thermo-optic phase shifters consist in heating a fiber core using an electrode in order to increase the optical index and then induce an artificial OPD. Thanks to the compactness of such systems, the heat transfert is fast enough to have response time of about $1\ ms$. These shifters have been designed to work optimally at $\lambda = 1.65\ \mu m$

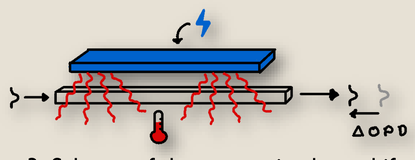


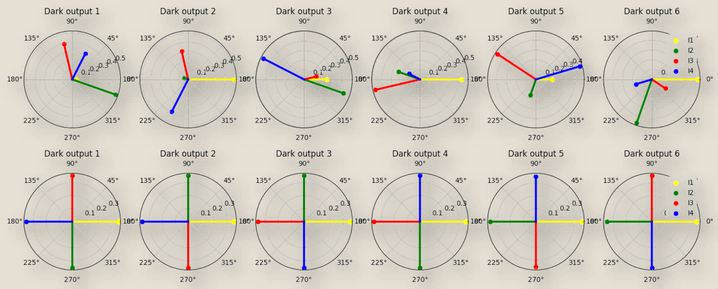
Figure 3: Scheme of thermo-optic phase shifter

Active optical components

The idea of our architecture is to combine the nulling interferometry with the phase shifter technologies to make an active optical component that can be calibrated to compensate the phase aberration induced by the manufacturing defects.

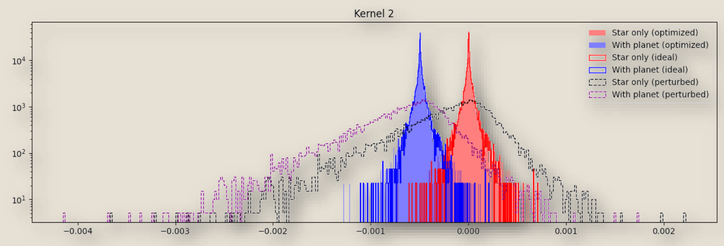
Calibration algorithme

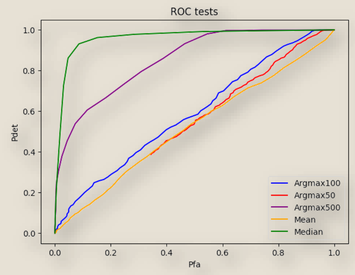
- Method
- Metrics
- Convergence speed
- Limitations

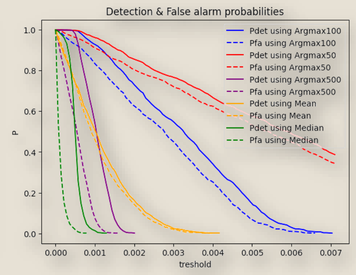


Statistical analysis

- Kernel outputs
- Distributions
- Estimation of the true value







Discussions & prospects

- Angular diversity
- Test in lab
- Usage of physics based MMI models
- Implementation on the VLTI

References

Blablabla

Acknowledgment

Blablabla

Financement projet PHOTONICS