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# CHARACTERIZATION OF EXOPLANET HOST STARS

## AND IMPACT OF PERTURBATING ELEMENTS

# OUTLINE

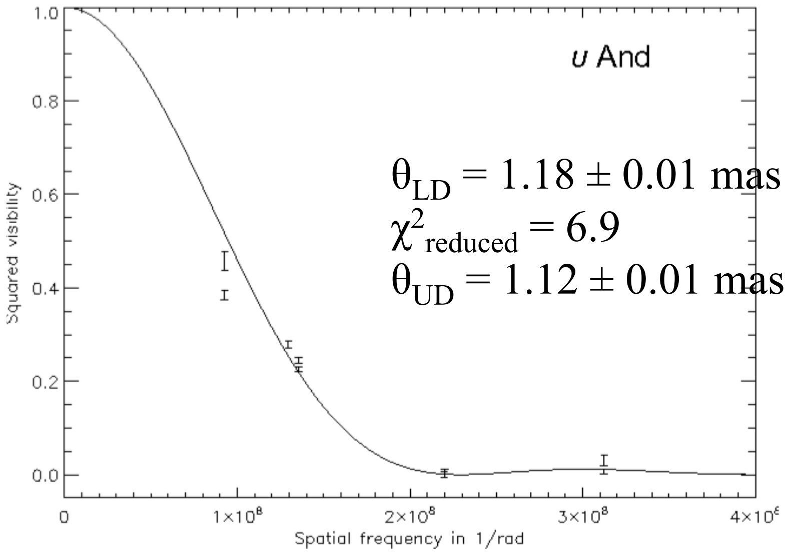
1. Previous results from observations with VEGA/CHARA
   1. Published results
   2. On-going results

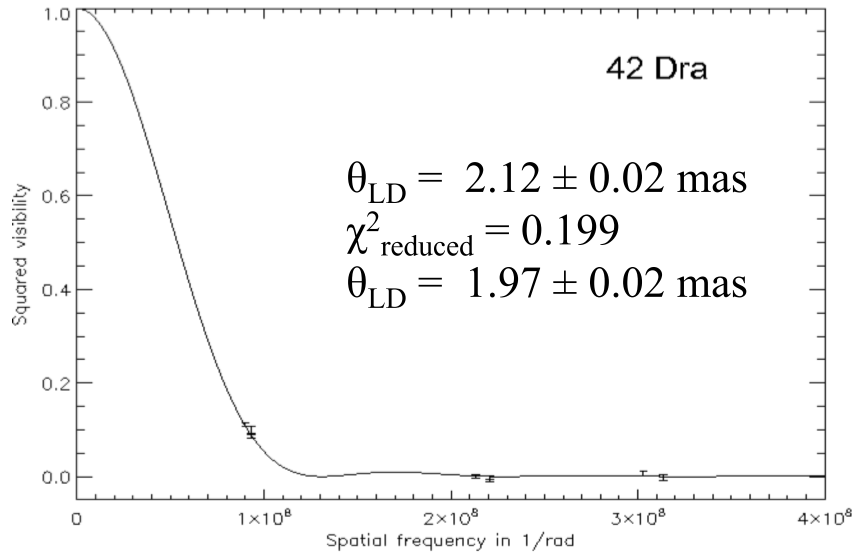
2. Modeling of transiting exoplanet and stellar spots
   1. Objective
   2. Method
   3. Results

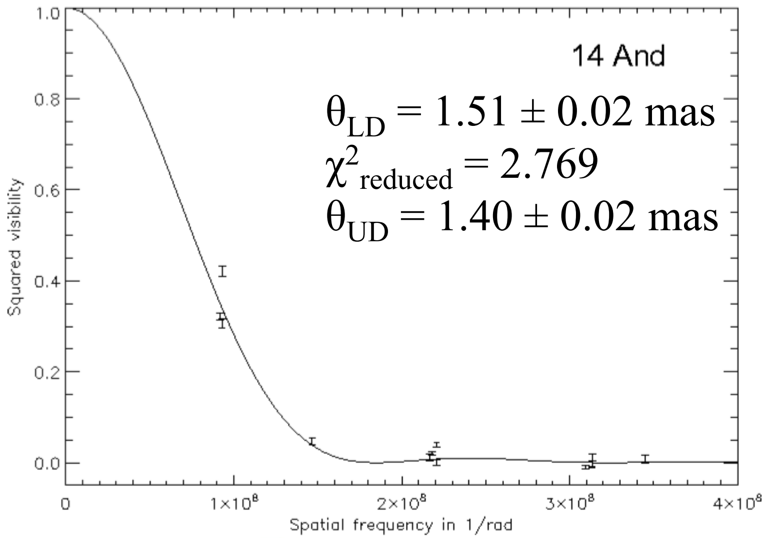
# PREVIOUS RESULTS FROM OBSERVATIONS WITH VEGA/CHARA

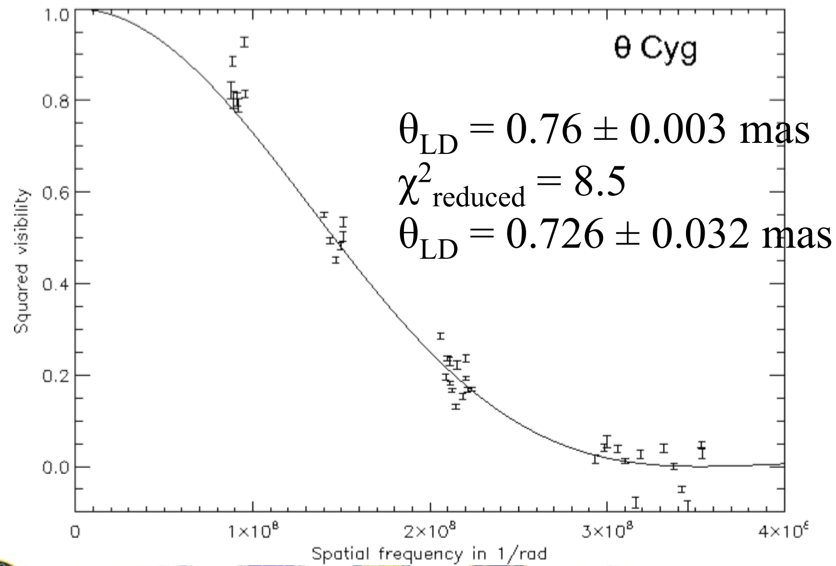
- Observations of exoplanet host stars from 2010 to 2012.
- Determination of fundamental parameters of observed stars and exoplanets.
- Good results in 2010-2011, less good in 2012…waiting for 2013 season.
- One paper published (Ligi et al., 2012).

# PUBLISHED RESULTS



# PUBLISHED RESULTS

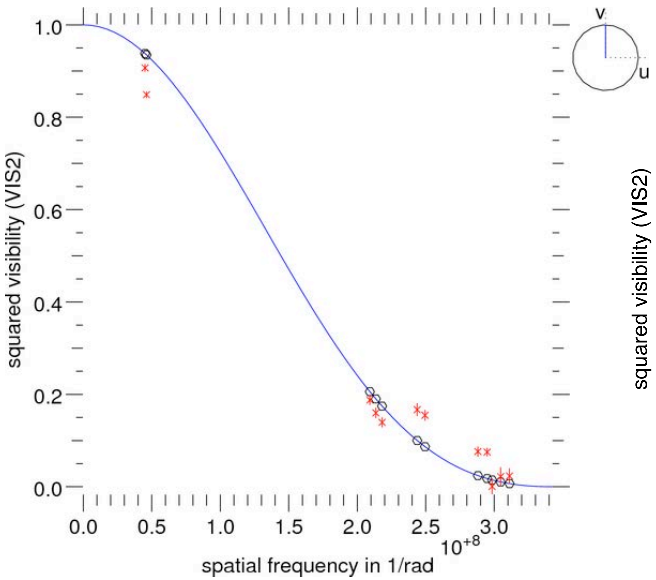
| Star | Radius | Mass | $T_{eff}$ |
|---|---|---|---|
| 14 And | 12.82±0.32 | 2.60±0.42 | 4450±78 |
| $\upsilon$ And | 1.70±0.02 | 1.12±0.25 | 5819±78 |
| 42 Dra | 22.04±0.48 | 0.92±0.11 | 4301±71 |

| Planet | $P_{orb}[days]$ | K $[m.s^{-1}]$ | e | $M_{pl}\sin(i)[M_{Jup}]$ This work | $M_{pl}\sin(i)[M_{Jup}]$ Previous work |
|---|---|---|---|---|---|
| 14 And b | 185.84±0.23 | 100.0±1.3 | 0 | 5.33±0.57 | 4.8[15] |
| $\upsilon$ And b | 4.62±0.23 | 70.51±0.45 | 0.022±0.007 | 0.62±0.09 | 0.69±0.04[22] |
| $\upsilon$ And c | 241.26±0.64 | 56.26±0.52 | 0.260±0.079 | 1.80±0.26 | 1.98±0.19[22] |
| $\upsilon$ And d | 1276.46±0.57 | 68.14±0.45 | 0.299±0.072 | 3.75±0.54 | 4.13±0.29[22] |
| $\upsilon$ And e | 3848.86±0.74 | 11.54±0.31 | 0.0055±0.0004 | 0.96±0.14 | 1.06±0.28[22] |
| 42 Dra b | 479.1±6.2 | 112.5 | 0 | 3.79±0.29 | 3.88±0.85[17] |

# ON-GOING RESULTS

- In 2012, observations of 7 exoplanet host stars.
- Bad forecast and instrumental difficulties prevented us to get good data in general.
- However, some data remain usable (up to now): 55 Cnc, HD19994, HD1367.
- Work still in progress.

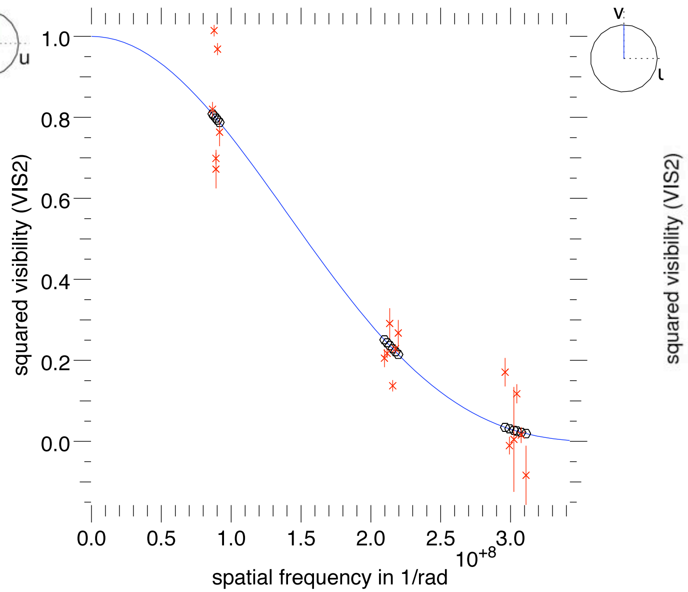
# ON-GOING RESULTS




## HD19994

- Host star, $\theta_{UD\ expected} \approx 0.75$ mas, magV = 5
- 1 exoplanet
- 3 observations during Fall 2012, 2 correct data points.

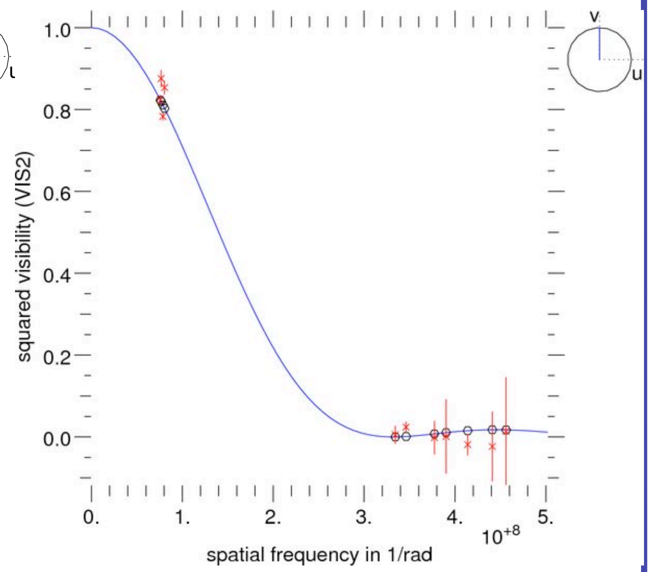
$\theta_{UD\ measured} \approx 0.74 \pm 0.005$ mas




## HD 1367

- Star, $\theta_{UD\ expected} \approx 0.63$ mas, magV = 6.2
- 3 observations during Fall 2012.

$\theta_{UD\ measured} \approx 0.69 \pm 0.005$ mas




## 55 Cancri

- Host star, $\theta_{UD\ expected} \approx 0.70$ mas, magV = 5.95
- 5 exoplanets, (1 transiting planet).
- 4 observations, 2 good data points.

$\theta_{UD\ measured} \approx 0.76 \pm 0.014$ mas

# ON-GOING RESULTS
## Conclusion

- Diameters to be confirmed.
- When conditions are good, we get good precisions on the measured diameters.
- We still have data to reduce in order to complete the star sample of 2012.

# MODELING OF TRANSITING EXOPLANETS AND STELLAR SPOTS

- Nowadays, more than 800 exoplanets have been detected.
- Many methods:
  - Radial velocity (RV): the most prolific one.
  - Transit method
  - Astrometry
  - Gravitationnal lens
- However, many difficulties to characterize them: $R_{pl}$, vsini, $M_{pl}$… are hard to measure with accuracy.
- Combining interferometry and RV measurements allows to accuratly determine $M_{pl}$sini.

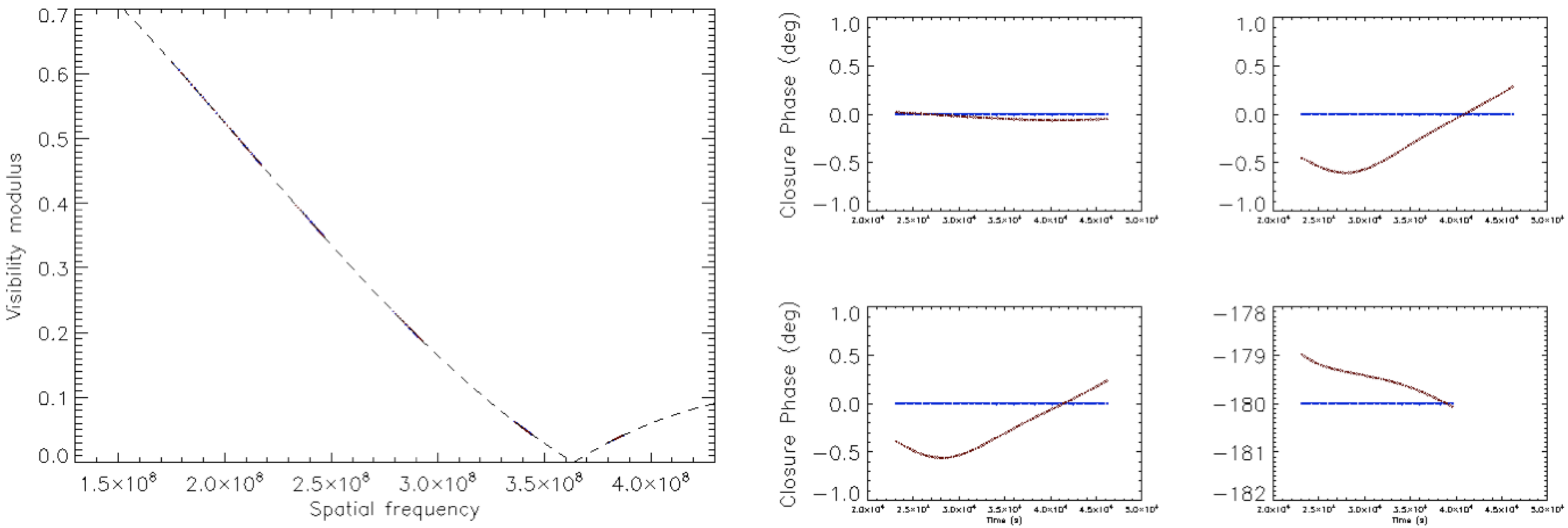
# OBJECTIVE

- Main goal: Which baseline length could detect the signature of a transiting exoplanet or a spot on the visibility or the closure phase?
- Is CHARA able to detect the signature of an exoplanet or a spot?
  - Study of the variation of each impact parameter
  - Study of the Minimum Baseline Length (MBL) needed to detect a transiting exoplanet or a spot according to these parameters.

# OBJECTIVE

Exemple: 55 Cnc observed with VEGA/CHARA, oifits file made with ASPRO2. $\theta_{pl}$=0.015 mas.

- Visibilities: nothing is detected.
- Closure phase: the signal does not exceed 1°.




Blue: without exoplanet

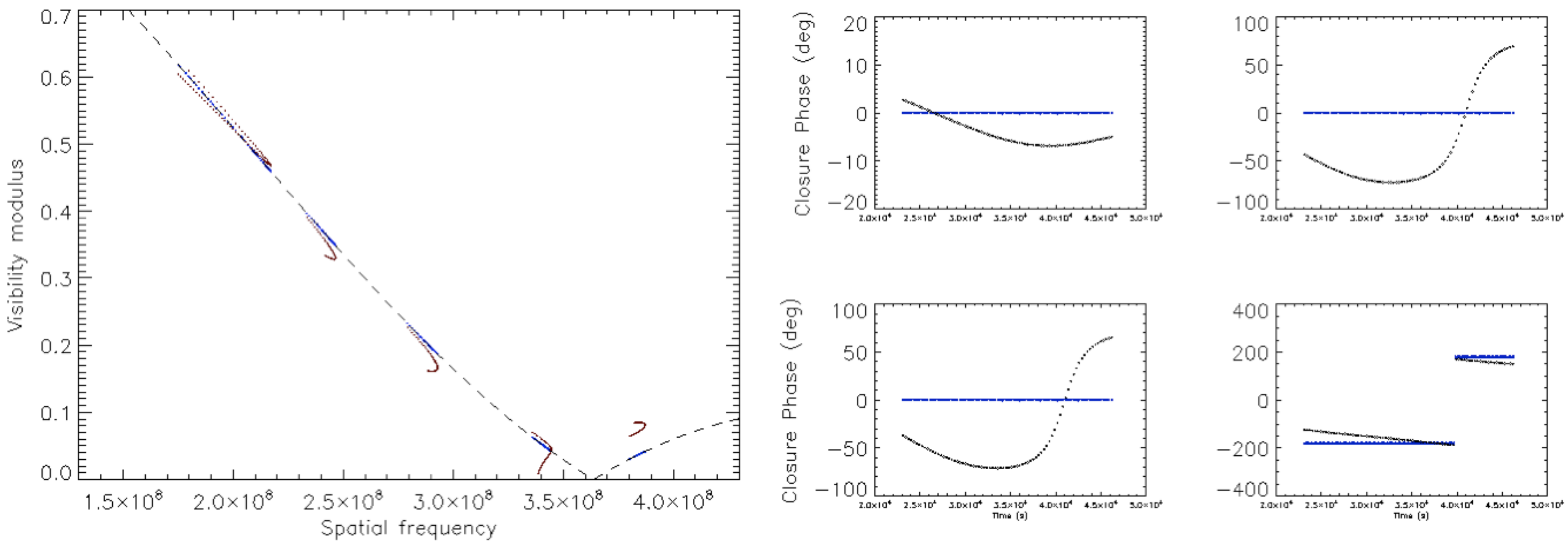
Red: with exoplanet

S1S2W2E2, $\theta_{LD}$= 0.74 mas

# OBJECTIVE

Illustrative exemple: a fictive 55 Cnc observed with VEGA/CHARA, oifits file made with ASPRO2. But we assume $\theta_{pl}$=0.15 mas.

- Visibilities: reach 6% difference close to the 0 of visibility.
- Closure phases: the signal reaches 100°.




Blue: without exoplanet
Red: with exoplanet

S1S2W2E2, $\theta_{LD}$= 0.74 mas

# OBJECTIVE

- We want to study the difference between the visibility modulus of a star without exoplanet and a star with a transiting exoplanet.
  - We look for differences of 1% and 2% between both.

- We want to study the difference between the closure phase of a star without exoplanet and a star with a transiting exoplanet.
  - We look for differences of 2° and 20° between both.

# METHOD

- Impact parameters: $\theta_*$, $\theta_{pl}$, location of the exoplanet $x$ or the spot, Claret coefficient α, Intensity of the spot $I_{spot}$.

- We fix every parameters but one, and make it vary.
  - ✧ Fixed values: $\theta_*$=1 mas, $I_{pl}$=0, $x$=0.2 mas, α=0.5.
  - ✧ Variation:
    - Of $x$: from 0 to 0.5 mas
    - Of $\theta_{pl}$: from 0.04 to 0.24
    - Of α for studying the impact of LD: from 0.44 to 0.74.
  - ✧ α, $x$ fixed, and variation of $\theta_{pl}/\theta_*$ (steady ratio).
  - ✧ α, $x$, $\theta_{spot}$, $\theta_*$ fixed, variation of $I_{spot}$.

# METHOD

- Analytical model: calculation of the visibility for a single star and for a star with a transiting exoplanet or a spot.
  - Stars: limb-darkened (LD) disks model.
  - Exoplanets: $I_{pl}=0$, assumed to be uniform dark disks.
  - For spots: their $T_{eff}$ can vary so $I_{spot}$ too, we assume LD disk models.

- For each parameter, we create baselines of 2 km large and calculate the corresponding visibilities and closure phases. We then compare with the visibility and the closure phase with no exoplanet.

NB: We settle for the calculation of phases only since we are not interested in one particular triplet telescopes, which would have allowed to calculate closure phases.

# RESULTS

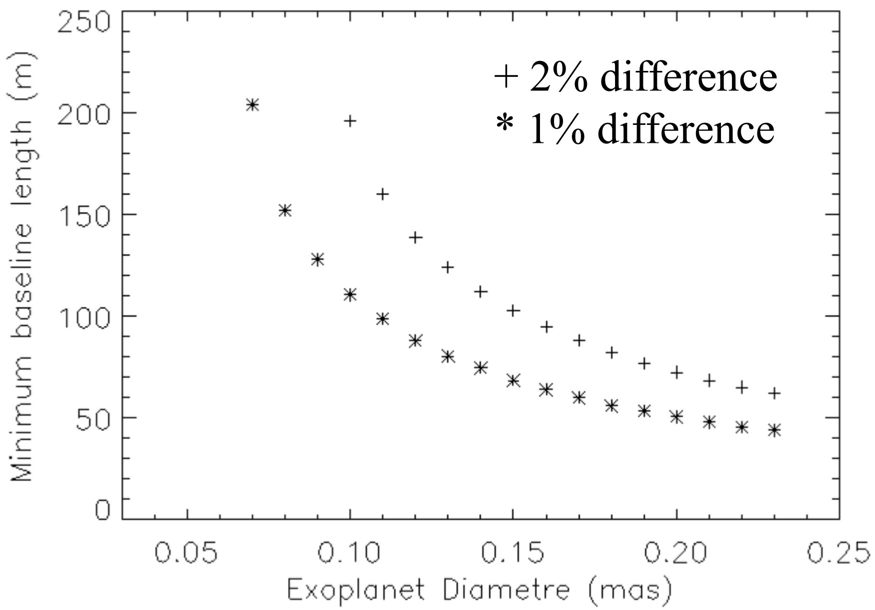
## Variation of exoplanet's diameter

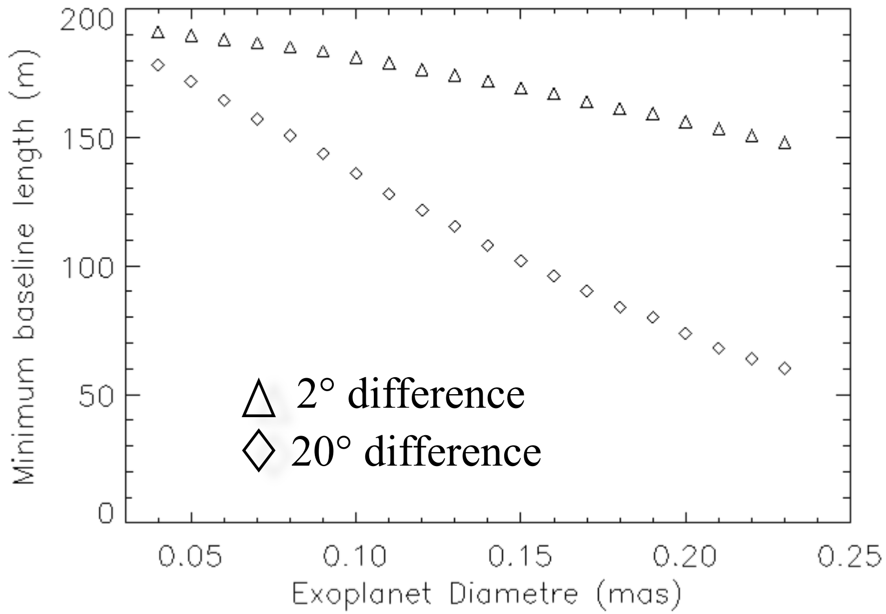
Variation of the Visibility:

No solution is found for $\theta_{pl} < 0.13$ mas for 2% difference. For $\theta_{pl} < 0.09$ mas, much larger baselines are needed.

Variation of the closure phase:

CHARA baselines exist.



# CONCLUSION

- In general, very small exoplanets ($\theta_{pl}$< 0.10 mas) need MBL>200m to be detected on the closure phase.
- Having more than 2% difference on the visibilities is not possible.
  - ➢ Need of the closure phases more than the visibility.
- For now, only big exoplanets (hot Jupiter, Neptune-like planets) have a chance to be detected by interferometry.
- The intensity of the spot would allow to disentangle between spots and exoplanets.

# CONCLUSION

VEGA catalog: ~10000 stars observable with CHARA, from -30° < δ < +90°.

Host stars accessible with VEGA/CHARA: 42 stars.

- 35.7% V
- 52.4% III
-11.9% IV

Criterium :
magV from 1.2 to 6.5
$0.3<\theta_*<3$ mas

Among them, only 1 transiting exoplanet, BUT 18 transiting exoplanets with magV<10 that will be observable with VEGAS...

| HD number | Spec. Type | Mag. V. |
|---|---|---|
| 3651 | K0 V | 5,80 |
| 9826 | F8 V | 4,09 |
| 14209 | K1IVa | 4,79 |
| 16400 | G5III | 5,65 |
| 19994 | F8 V | 5,07 |
| 22049 | K2 V | 3,73 |
| 28305 | K0 III | 3,53 |
| 32518 | K1III | 6,44 |
| 45410 | K0IV | 5,86 |
| 47205 | K1 III | 3,96 |
| 59686 | K2 III | 5,45 |
| 62509 | K0IIIb | 1,15 |
| 69830 | K0V | 5,95 |
| 73108 | K1III | 5,79 |
| 75732 | G8 V | 5,95 |
| 81688 | K0III-IV | 5,41 |
| 95128 | G0V | 5,10 |
| 100655 | G9III | 6,45 |
| 104985 | G9 III | 5,79 |
| 107383 | G8 III | 4,74 |
| 110014 | K2III | 4,66 |
| 115617 | G5V | 4,74 |
| 117176 | G4 V | 5,00 |
| 120136 | F7 V | 4,50 |
| 122430 | K3III | 5,48 |
| 136726 | K4III | 5,02 |
| 137759 | K2III | 3,31 |
| 139357 | K4III | 5,98 |
| 143761 | G0V or G2V | 5,40 |
| 167042 | K1III | 5,97 |
| 170693 | K1,5III | 4,83 |
| 173416 | G8 | 6,06 |
| 188310 | G9IIIb | 4,72 |
| 190360 | G6 IV | 5,71 |
| 192310 | K1V | 6,13 |
| 199665 | G6III | 5,52 |
| 210702 | K1III | 5,93 |
| 216956 | A3 V | 1,16 |
| 217014 | G2 IV | 5,49 |
| 219449 | K0 III | 4,21 |
| 221345 | K0III | 5,22 |
| 222404 | K2 V | 3,22 |

# PERSPECTIVES

- The method could be improved: the flattening of spots, while exoplanets remains round all along their journey in front of the star, could add more hints to disentangle between exoplanets.
- Only one exoplanet or spot is modeled:
  - ok for transiting exoplanets in general
  - spot generally come by pairs, and their can be many on a same star.
    - ➢ Lead to a numerical model.

# THANK YOU

## FOR YOUR ATTENTION