Host stars investigations with VEGA/CHARA

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Outline

- Context: observing host stars.
- Observations of three chosen host stars:
  - 14 And
  - u And
  - 42 Dra
- The case of indomitable θ Cygni.
  - Results
  - Variations of the diameter
- Conclusions.

CONTEXT

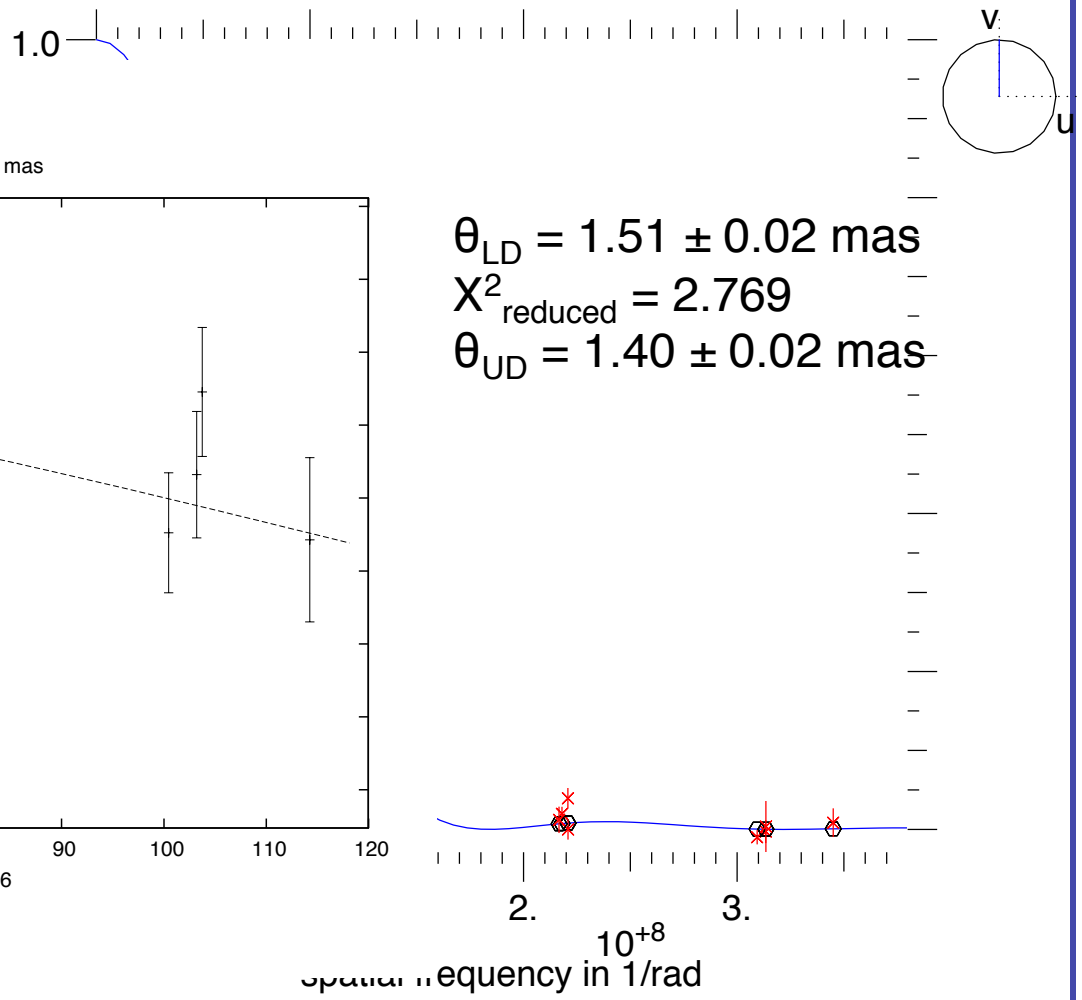
Why observing host stars?

- To understand better the link between stars and the presence of exoplanets.
- Need of missing stellar parameters (radii....) and of the influence of perturbating elements (spots, LD, …) to study stellar evolution.
- Study of the sample

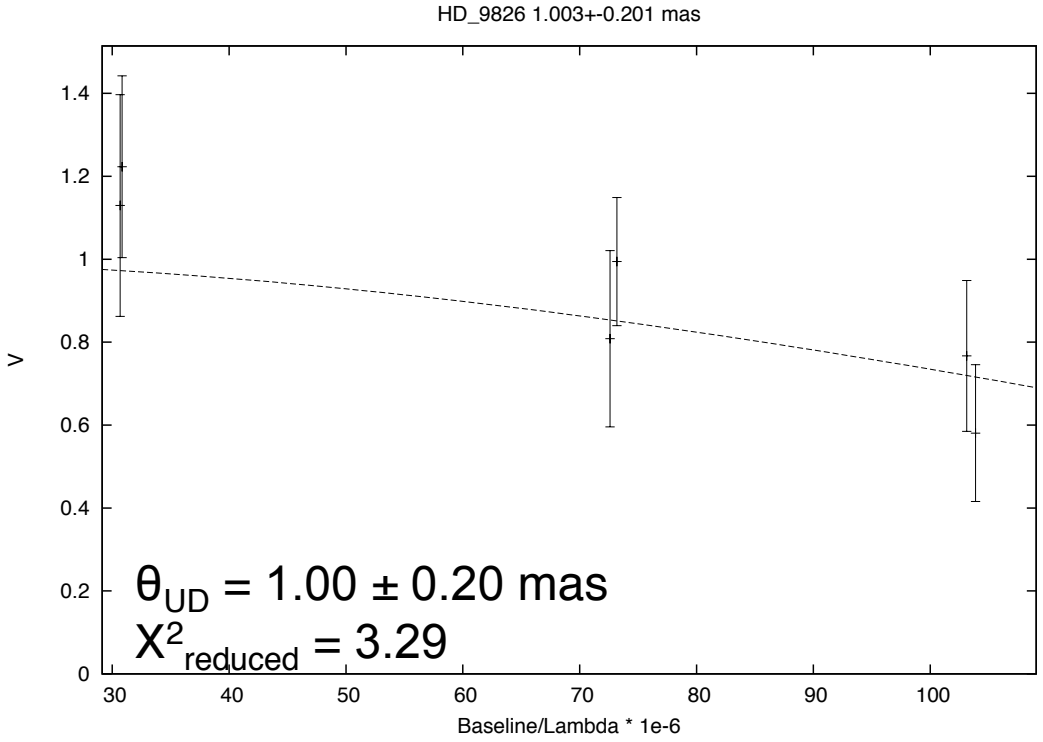
Exoplanets host stars observable by VEGA/CHARA, ≈ 40 stars (ANR «100 Stars»):
F, G or K stellar type
Diameter < 2mas
Mag V < 6

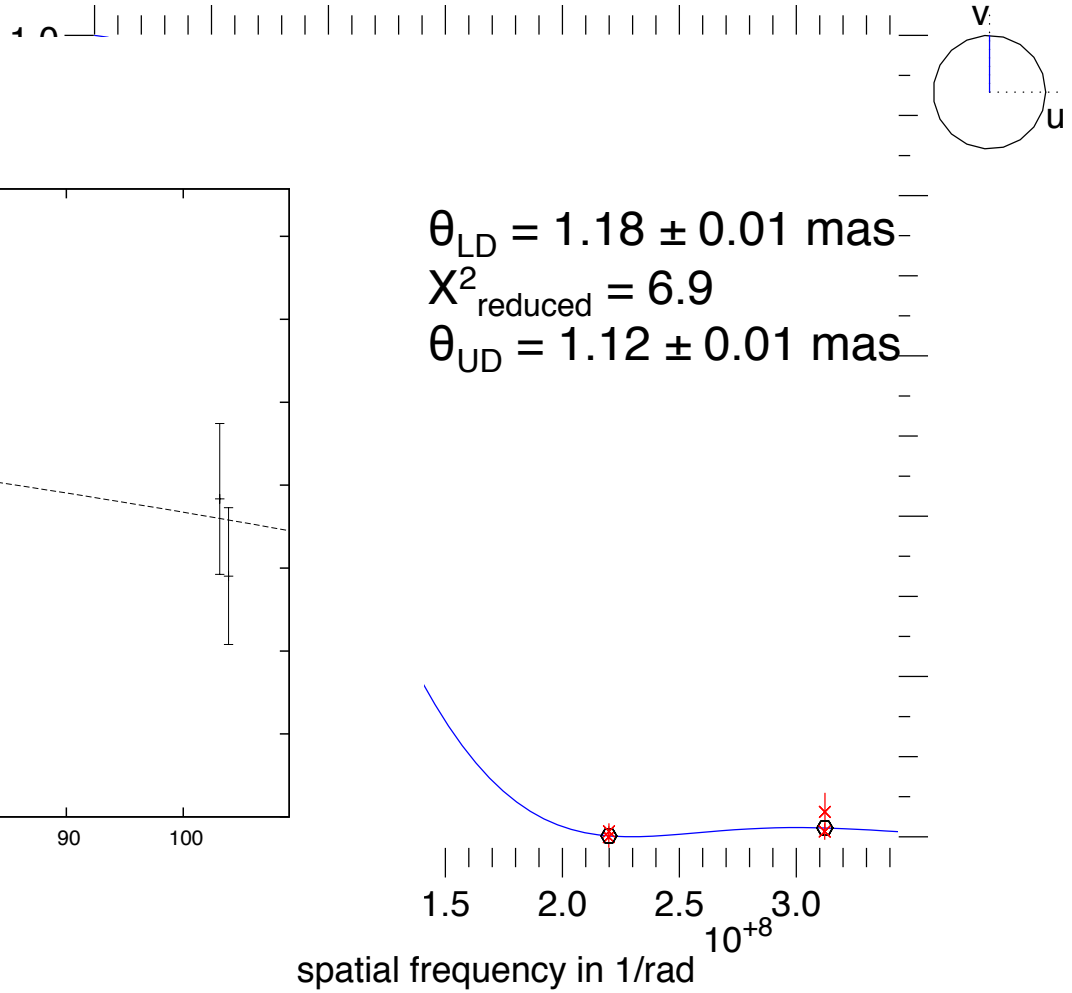
OBSERVATIONS OF HOST STARS

14 And

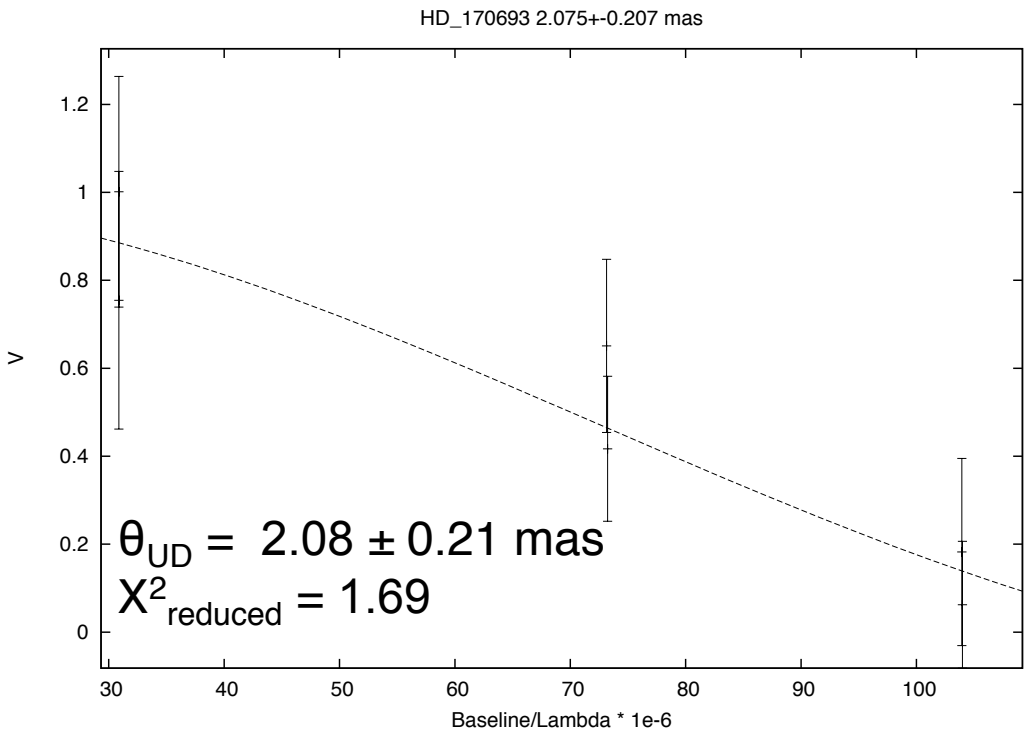

1.0
V
u
HD_221345 1.267+-0.147 mas
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
V
30
40
50
60
70
80
90
100
110
120
Baseline/Lambda * 1e-6
θUD = 1.27 ± 0.15 mas
X2reduced = 9.13
θLD = 1.51 ± 0.02 mas
X2reduced = 2.769
θUD = 1.40 ± 0.02 mas
2.
3.
10+8
Spatial frequency in 1/rad

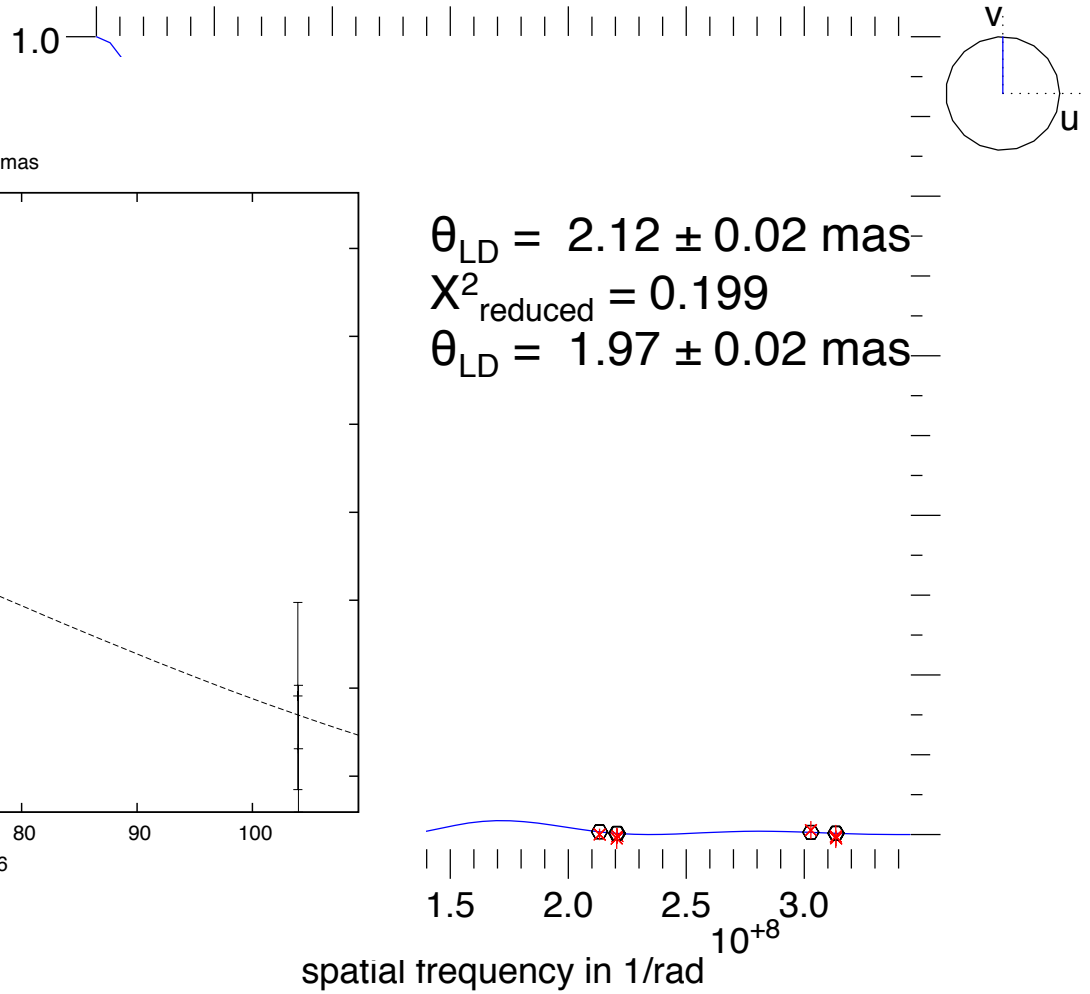
u And


HD_9826 1.003+-0.201 mas
V
Baseline/Lambda * 1e-6
θUD = 1.00 ± 0.20 mas
X2reduced = 3.29


v
u
θLD = 1.18 ± 0.01 mas
X2reduced = 6.9
θUD = 1.12 ± 0.01 mas
10+8
spatial frequency in 1/rad

42 Dra


HD_170693 2.075+-0.207 mas
V
Baseline/Lambda * 1e-6
θUD = 2.08 ± 0.21 mas
X2reduced = 1.69


1.0
v
u
θLD = 2.12 ± 0.02 mas
X2reduced = 0.199
θLD = 1.97 ± 0.02 mas
1.5
2.0
2.5
3.0
10+8
spatial frequency in 1/rad

Fundamental parameters of stars

- Radius: $R \pm \delta R = \frac{\theta_{LD} \pm \delta\theta_{LD}}{9.305 \times (\pi \pm \delta\pi)}$
- Mass: $g = -GM/R^2$
- Effective temperature: $L = 4\pi R^2 \sigma T_{eff}^4$

Sato et al., 2008: M = 2.2 M_{sol}

Furhmann et al., 1998: M = 1.27± 0.06 M_{sol}

Döllinger et al., 2009: M = 0.98 ± 0.05

Star	θ_{LD} [mas]	$\chi^2_{reduced}$	π	Radius [$R_\odot$]	Mass [$M_\odot$]
14 And	1.51±0.02(1.3)	2.769	12.63±0.27(2.1)	12.82±0.32(2.5)	2.60±0.42(16)
υ And	1.18±0.01(0.9)	6.9	74.12±0.19(0.3)	1.70±0.02(0.9)	1.12±0.25(22)
42 Dra	2.12±0.02(0.9)	0.199	10.36±0.20(1.9)	22.04±0.48(2.2)	0.92±0.11(12)

Errors dominated by the parallax!

Exoplanets parameters

$$\frac{(m_p \sin i)^3}{(m_\star + m_p)^2} = \frac{P}{2\pi G} K^3 (1-e^2)^{3/2}$$

Eggengerger, A. et Udry, S., 2009

Sato et al., 2008: M_{pl}sini = 4.8 M_{Jup}

Curiel et al., 2011: M_{pl}sini = 0.69, 1.98, 4.13 and 1.1 M_{Jup} for u And b, u And c, u And d and u And e respectively.

Döllinger et al., 2009: M_{pl}sini = 3.9 M_{Jup}

Star	Planet	P_{orb} [d]	e	$M_{pl}sini$ [M_{Jup}]
14 And	14 And b	185.84±0.23	0	5.31
υ And	υ And b	4.6±0.2	0.02±0.01	0.62
				1.79
	υ And d	1276.5±0.6	0.30±0.07	3.74
	υ And e	3848.9±0.7	0.01±0.00	0.96
42 Dra	42 Dra b	479.1±6.2	0	3.78

Results in good agreements with previous results!

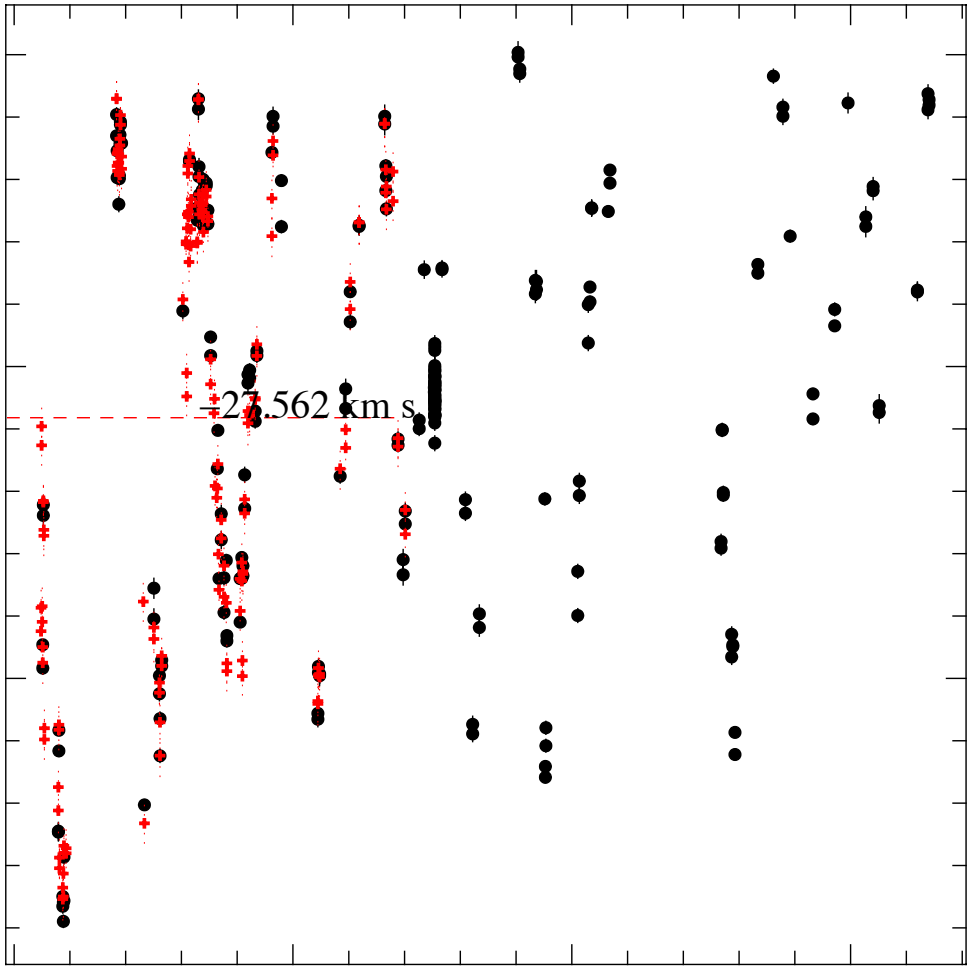
THE CASE OF INDOMITABLE θ CYGNI

θ Cygni

- M dwarf companion orbiting at 46 of angular separation, contrast of V band) *(Desort et al., 2009)*.
- Kepler target ➔ photometric obse led to the detection of solar-like oscillations.
- Spectroscopic observations with and SOPHIE (OHP) ➔ quasi-per RV of ≈150 days.

➔ More than 3 exoplanets? Co-o planets in resonance? *(Desort 2009).*

RV by Anne-Marie Lagrange with SOPHIE (OHP)

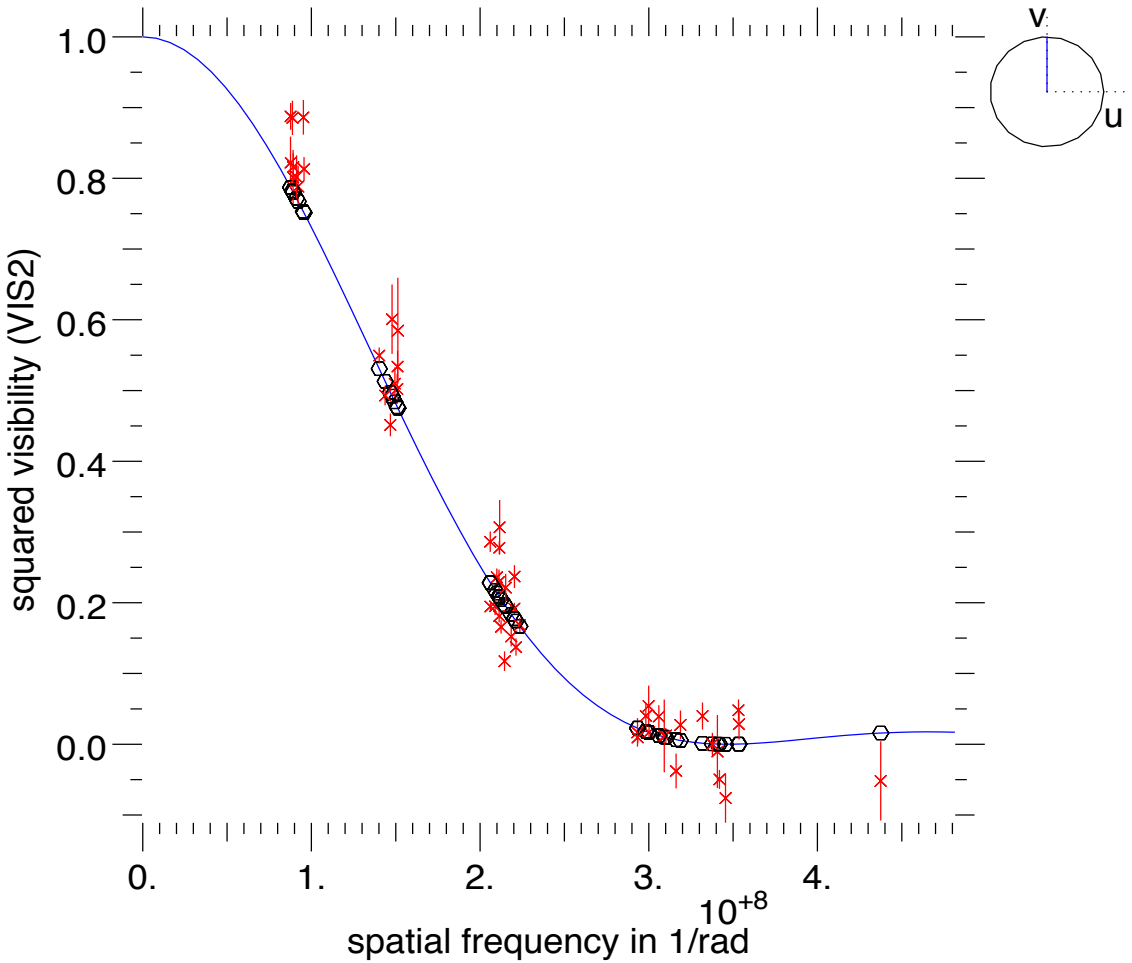


Julian Day – 2454000

Observations

- From June 2010 to November 2011
- E2E1W2, W2W1E1 and W2W1E2
- 3 different calibrators
- Sequence of observations:
  cal – target – cal

➔ Dispersed results!



Results

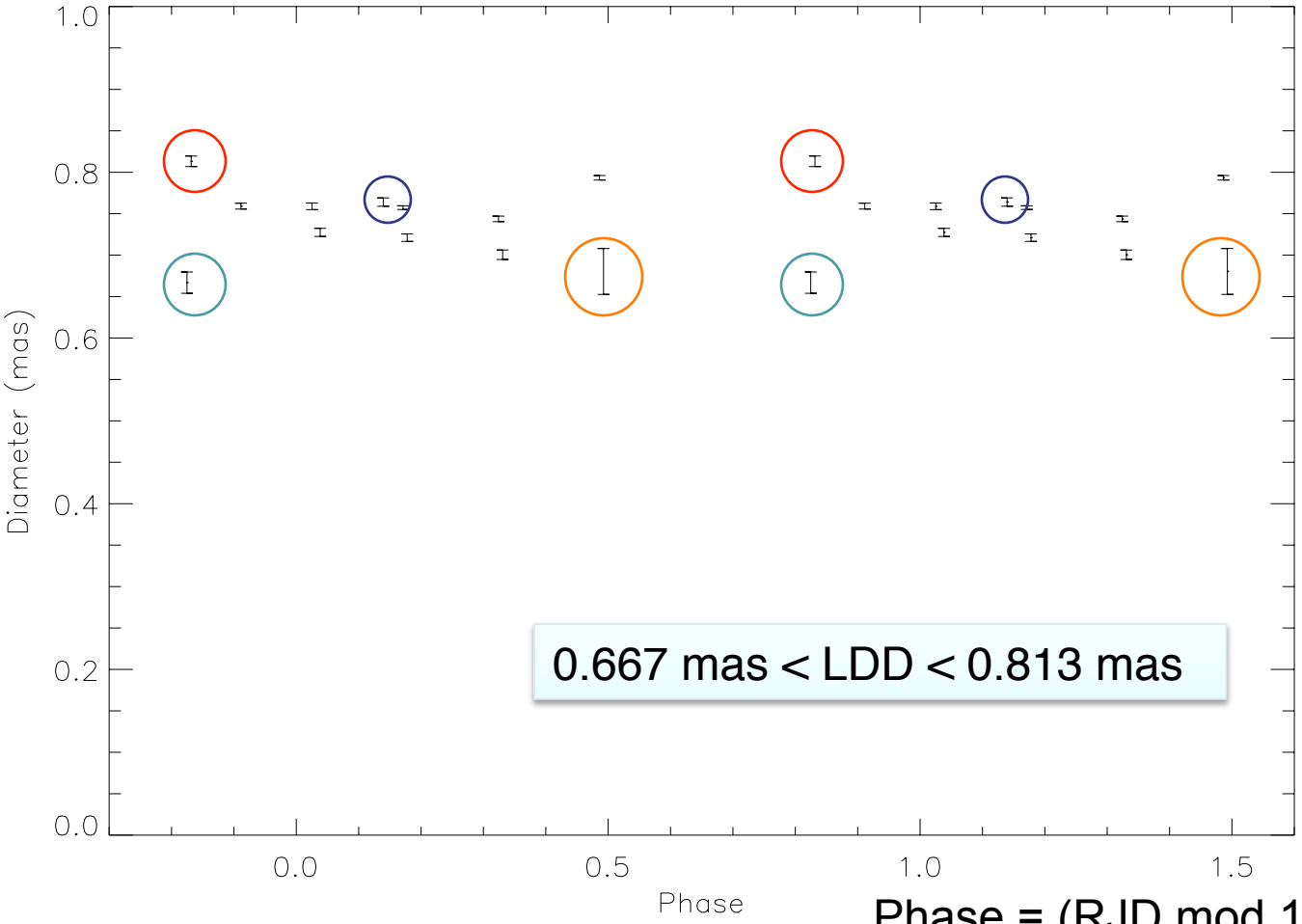
Stellar parameters	Value±Error
LD diameter [*mas*]	0.760±0.002(0.3)
Radius [$R_\odot$]	1.490±0.006(0.4)
Mass [$M_\odot$]	1.30±0.14(11)

Radius =1.70 ± 0.03
(Boyajian et al. 2012)
Radius =1.50 ± 0.04
(van Belle et al., 2008)

θ_{LD} = 0.861 ± 0.015
(Boyajian et al. 2012)

Mass=1.34 ± 0.01
(Boyajian et al. 2012)
Mass =1.38 ± 0.05
(Desort et al., 2009)

Variations of θ Cygni's diameter



Phase = (RJD mod 150)/150

Variations of θ Cygni's diameter

- Periodical radial velocity of 150 days: link with the variation of the diameter?
- Waiting for closure phases…
- Other possible causes:
  - A second unknown companion, which would exchange flux with the host star?
  - Stellar activity? *(Desort et al, 2009)*.

CONCLUSIONS

Conclusion (1/2)

- Perspectives:
  - Direct determination of LD coefficients,
  - Need to improve the calculation of error bars.
- Improved modeling (Cesam2K):
  - T_{eff} and metallicity,
  - Mass and age.

- Good method to derive M_{pl}sini.
- To be applicated to transiting exoplanets to directly deduce planets radii.

Conclusion (2/2)

- Validity of the measurements with the observations of 14 And, υ And and 42 Dra.

- θ Cygni shows dispersed results, but the other measurements prove that VEGA provide good quality data.

  ➔ Intrinsic variations from the star?

- We know that this star has been showing interesting but not understood patterns since it has been observed.

  ➔ Star not fully understood yet, the investigations continues…


Thank you for your attention