Interferometric observations of young and evolved stars

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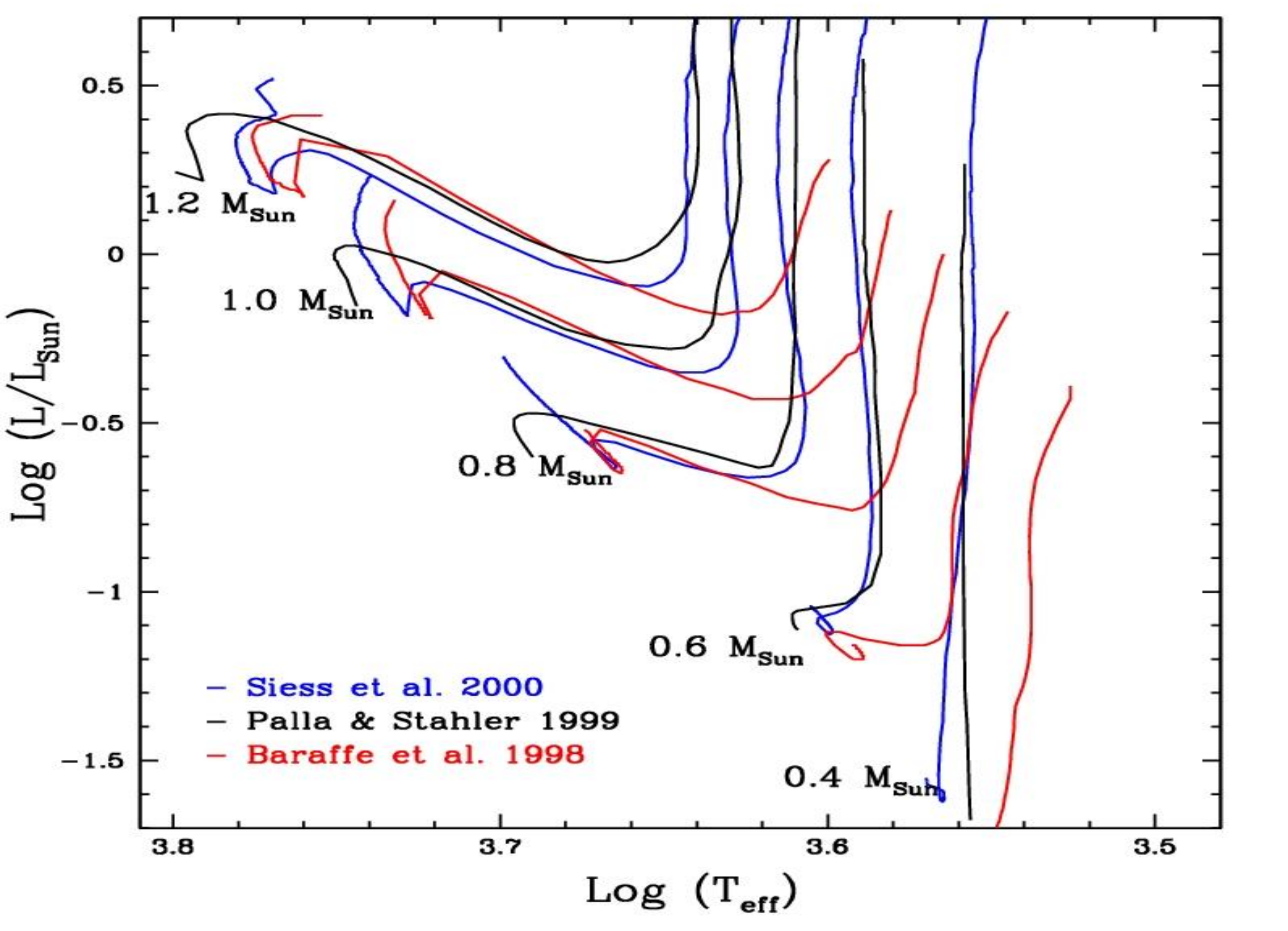
I.Testing evolutionary tracks of PMS stars:why?

- Masses of PMS stars in star forming regions are determined by using evolutionary tracks

- Different authors use different input physics

- For a star of given luminosity and temperature, different tracks can give different mass values up to 50-60%



0.5
0
−0.5
−1
−1.5
3.8
3.7
3.6
3.5
Log (L/L_Sun)
Log (T_eff)
1.2 M_Sun
1.0 M_Sun
0.8 M_Sun
0.6 M_Sun
0.4 M_Sun
– Siess et al. 2000
– Palla & Stahler 1999
– Baraffe et al. 1998

I.Testing evolutionary tracks of PMS stars:method

Measure dynamical masses of stars in binary systems using S+Opt Interferometry

1° step

Spectroscopic survey on more than 100 young stars to search for binaries

2° step

Determination of the spectroscopic orbit and collection of a sample of 13 young binaries with period > 50 days
(exchanges of mass avoided) Guenther et al. 2007

Short period binaries are active connected
(e.g. RX J1603.8-3938 P~8d same masses but different luminosities, Guenther et al. 2001)

3° step

Observing the binaries with AMBER@VLTI

The SB canditates

Table 1. Spectroscopic binaries with periods longer than 50 days.

	This survey/ region	*EW* Hα	*EW* LiI [Å][1]	Spec type [Å]	m_K type	RA [mag]	Dec (2000.0)	Type (2000.0)	Period [days]
HIP50796[2]	no / TWA	0.20[3]		K5/WTTS	7.66 ± 0.03	10 22 18.0	−10 32 15	SB1	570
CS Cha	yes / Cha	−40	0.53 ± 0.01	K4/CTTS	8.20 ± 0.03	11 02 26.3	−77 33 36	SB1	≥2482
HD97131[4]	no / TWA			F2	7.70 ± 0.02	11 10 34.2	−30 27 19	ST3	134
RX J-7539	yes / Cha	fi	0.21 ± 0.06	K2/WTTS	7.93 ± 0.02	12 20 34.4	−75 39 29	SB1	613
MO Lup[5]	yes / Lup	−2.3	0.37 ± 0.02	K7/WTTS	8.64 ± 0.02	15 24 03.5	−32 09 51	ST3	>3000
RX J1534.1-3916	yes / Lup	abs	0.21 ± 0.02	K1/WTTS	8.55 ± 0.02	15 34 07.4	−39 16 18	SB1	>3000
RX J1559.2-3814	yes / Lup	−1.4	0.23/0.14	WTTS	9.34 ± 0.03	15 59 16.1	−38 14 42	SB2	474
GSC 06209-00735	yes / SC	0.3	0.37 ± 0.01	K2/WTTS	8.43 ± 0.02	16 08 14.8	−19 08 33	SB1	2045
NTTS160814-1857[6]	no / SC	0.7		K2/WTTS	7.69 ± 0.02	16 11 09.0	−19 04 45	SB1	145
GSC 06213-00306	yes / SC	fi	0.24/0.18	WTTS	7.43 ± 0.02	16 13 18.5	−22 12 48	SB2	167
Haro 1-14c[7]	no / Oph			K3/WTTS	7.78 ± 0.03	16 31 04.4	−24 04 33	SB2	591
NTTS162819-2423s[6]	no / Oph	em		G8/WTTS	7.44 ± 0.02	16 31 20.0	−24 30 04	SB1	89
BS Indi[8]	yes / Tuc	abs	0.18 ± 0.02	K0/WTTS	6.57 ± 0.02	21 20 59.8	−52 28 40	SB1	1222

Guenther et al. 2007

HD113449	yes/Abdor	abs	0.142	K0	5.51	13 03 49.7	-05 09 42	SB1	216

young SB1 system found in the cause
of exoplanet-hunting with HARPS@3.6m
Esposito et al in preparation

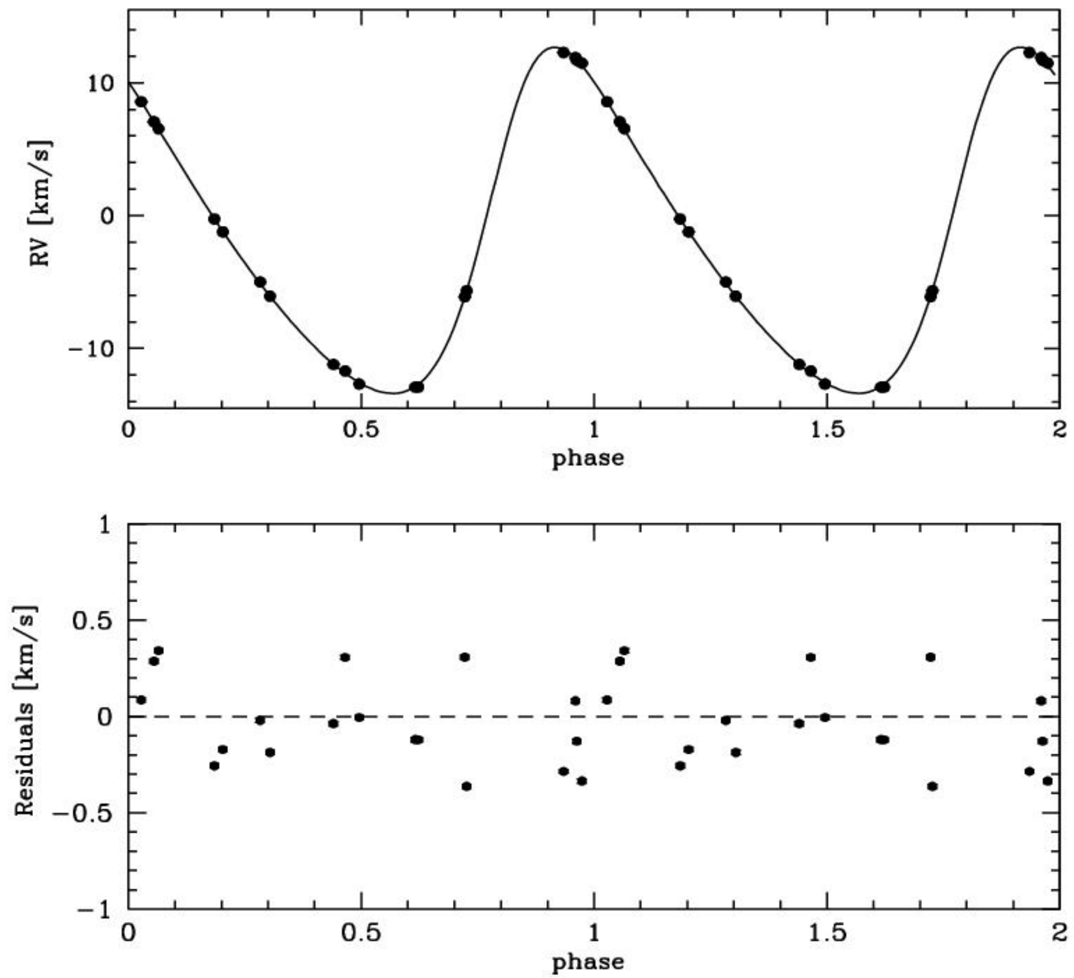
HD113449

d= 21.70 ± 0.40 pc
H=5.674 ± 0.038 mag
K=5.509 ± 0.023 mag
EW(Li λ6708)=0.142 Å

member of AB Dor association
SB1 system

Parameter	Value
P	215.96 ± 0.11 d
T_0[HJD]	2450174.9 ± 0.1
γ	-1.98 ± 0.02 km s^{-1}
K_1	13.03 ± 0.02 km s^{-1}
e	0.270 ± 0.005
ω	$117.2 \pm 0.5°$
$a_1 \sin i$	0.249 ± 0.001 AU
f(m)	0.0442 ± 0.0003 $M_\odot$

Table 5.1: Orbital elements of HD113449



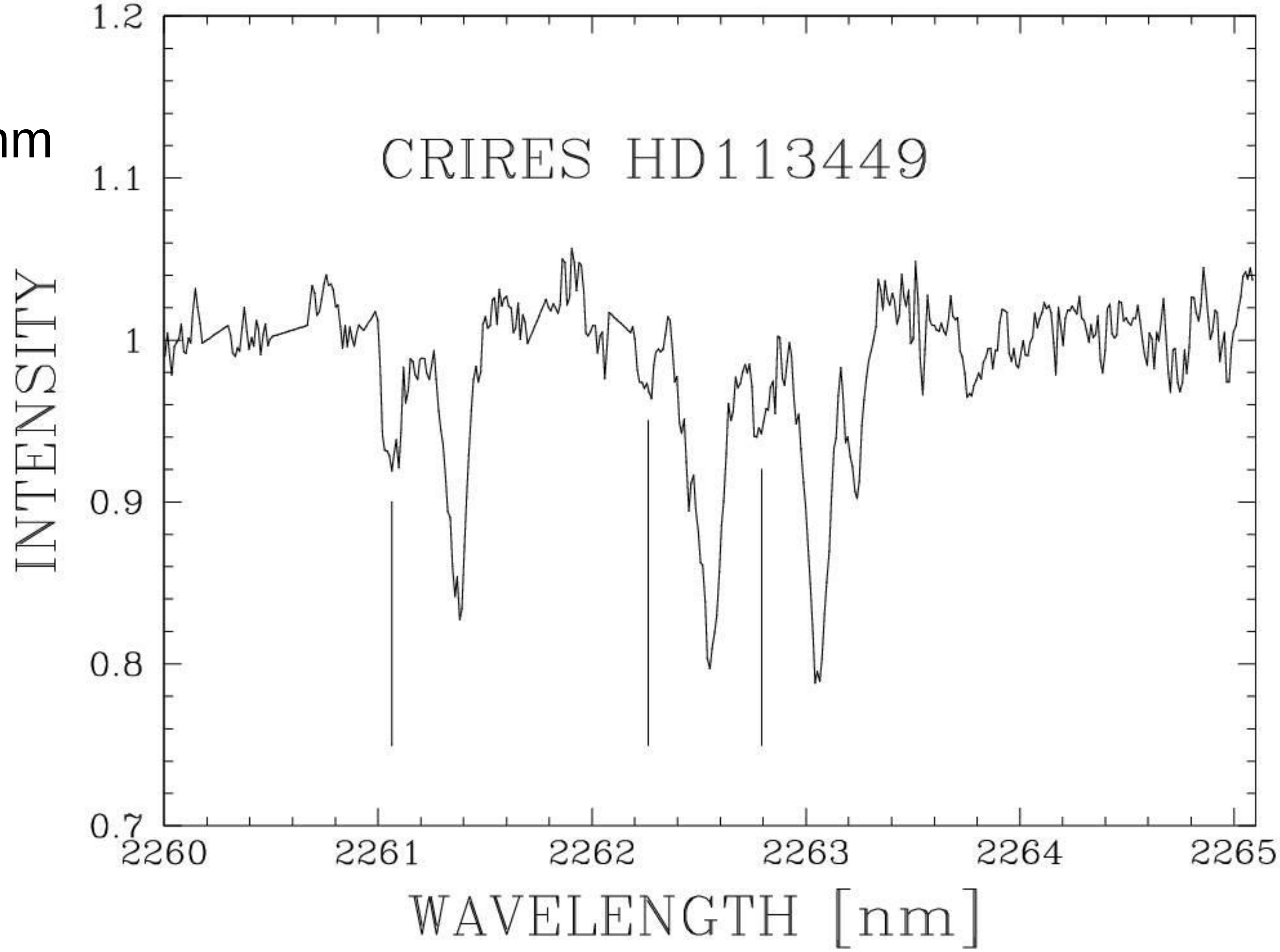
HD113449 observed with CRIRES

R~100000

$\Delta\lambda$=2253.97-2304.57 nm

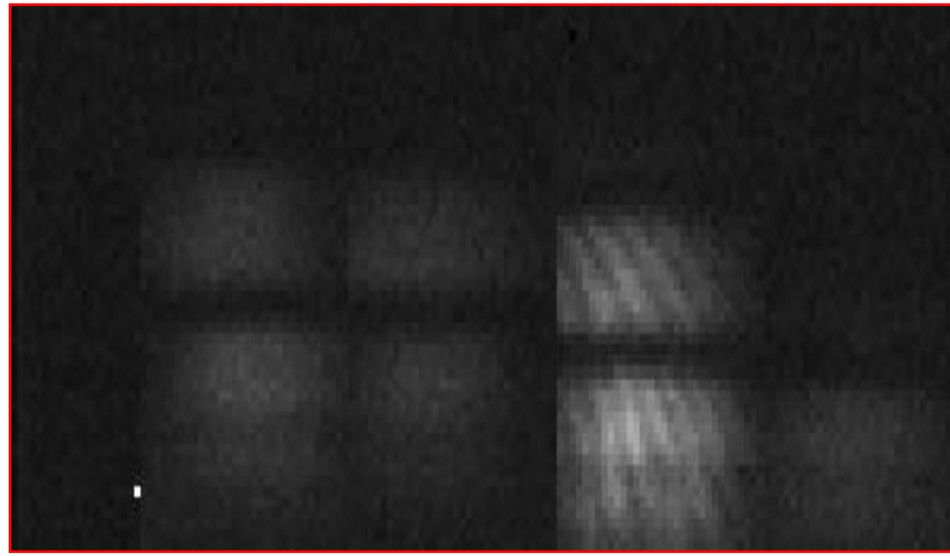
with N_2O cell

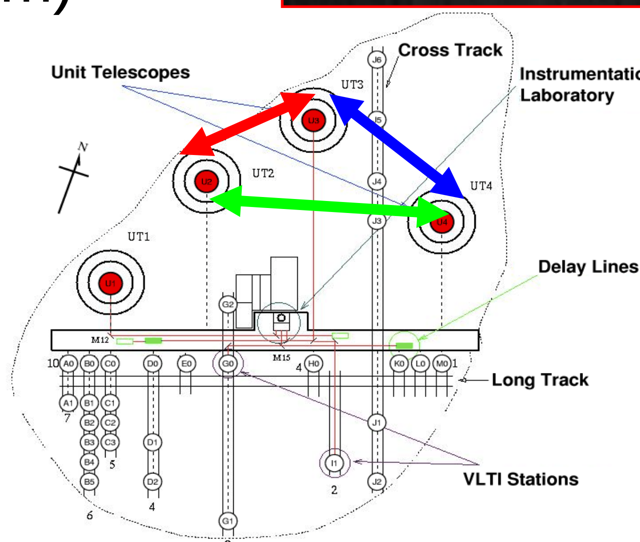
M_2/M_1=0.58±0.03

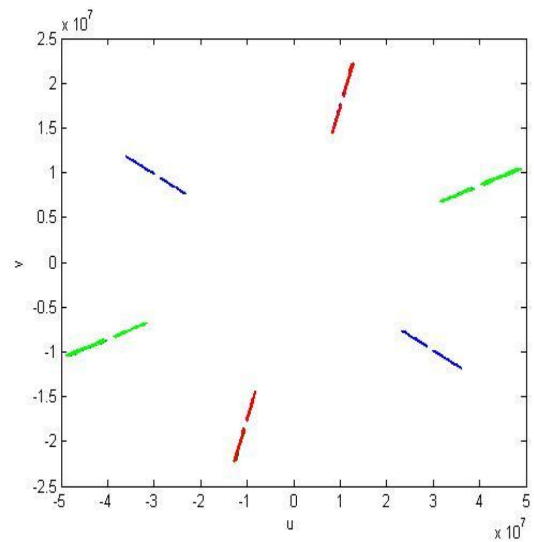


AMBER observation of HD113449

- Observed the 21 March 2008
- 6 consecutive exposure (data cube composed of 1000 frame of t=25 ms)
- 3 baseline UT2, UT3 and UT4 (max B=89m)
- Calibration star HD111998







Models

$$V^2 = \frac{1 + f^2 + 2f\cos[2\pi(B_x Ra + B_y Dec)/\lambda]}{(1+f)^2}$$

$Ra = A(\cos E - e) + B(1-e^2)^{1/2} \sin E$

$Dec = C(\cos E - e) + D(1-e^2)^{1/2} \sin E$

$M = 2\pi(t_{obs} - \tau)/P$

$M = E - e\sin E$

$A = a(\cos\omega\cos\Omega - \sin\omega\sin\Omega\cos i)$

$B = a(-\sin\omega\cos\Omega - \cos\omega\sin\Omega\cos i)$

$C = a(\cos\omega\sin\Omega + \sin\omega\sin\Omega\cos i)$

$D = a(-\sin\omega\cos\Omega + \cos\omega\sin\Omega\cos i)$

B_x=projected x baseline
B_y=projected y baseline
f=flux ratio at λ
E=eccentric anomaly
M=mean anomaly
t_{obs}=jd of observation
τ=time of periastron
P=period
e=eccentricity
ω=longitude of periastron
Ω=longitude of ascendig node
i=inclination
a=semimajor axes

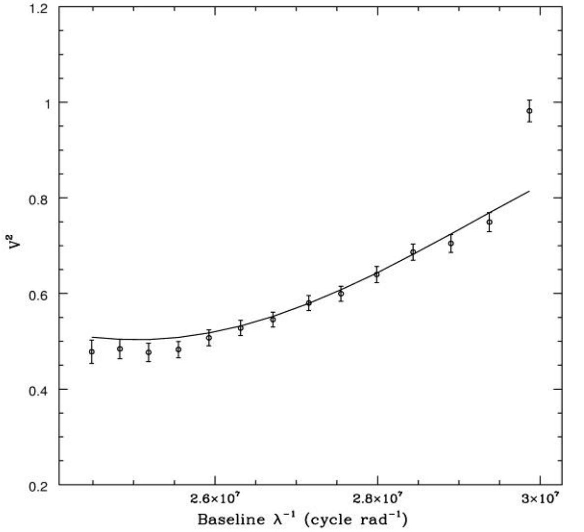
Results

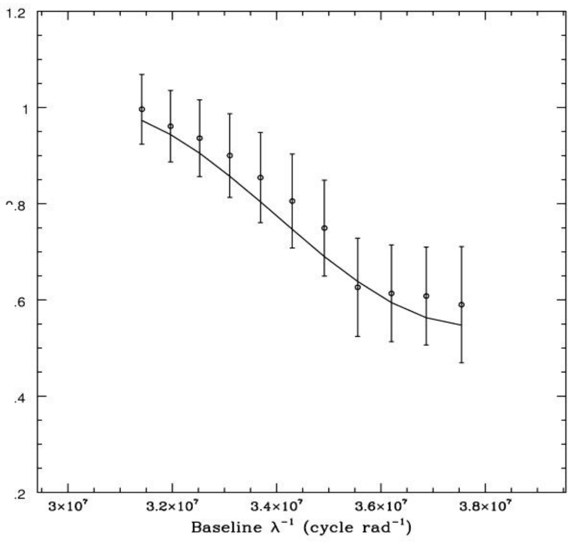
i=57±3°

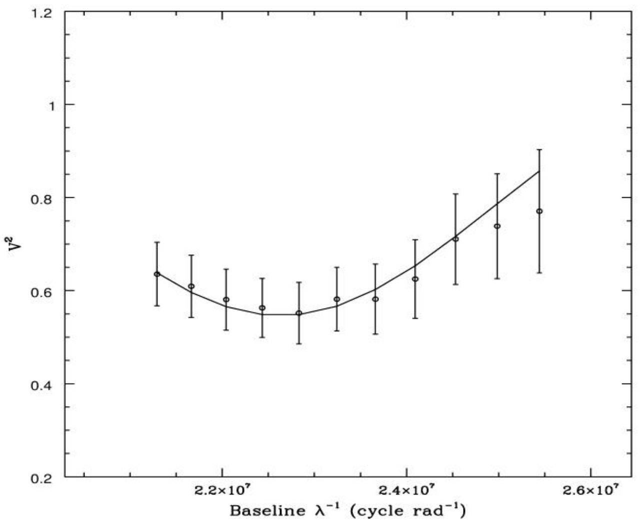
Ω=138±4°

f(K)=0.17±0.02

f(H)=0.15±0.02







M_1=0.96±0.09 $M_☉$

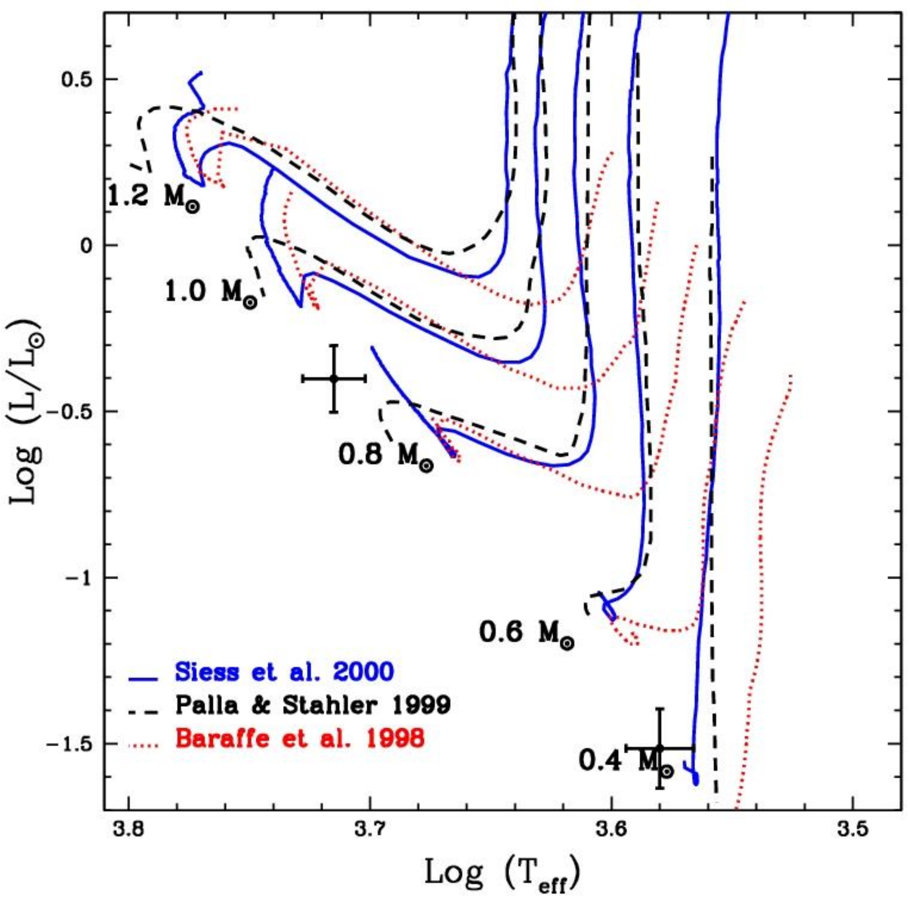
M_2=0.56±0.05 $M_☉$

HR diagram of HD113449

Siess
M_1=0.88 $M_☼$
M_2=0.43 $M_☼$
coeval
t=150Myr

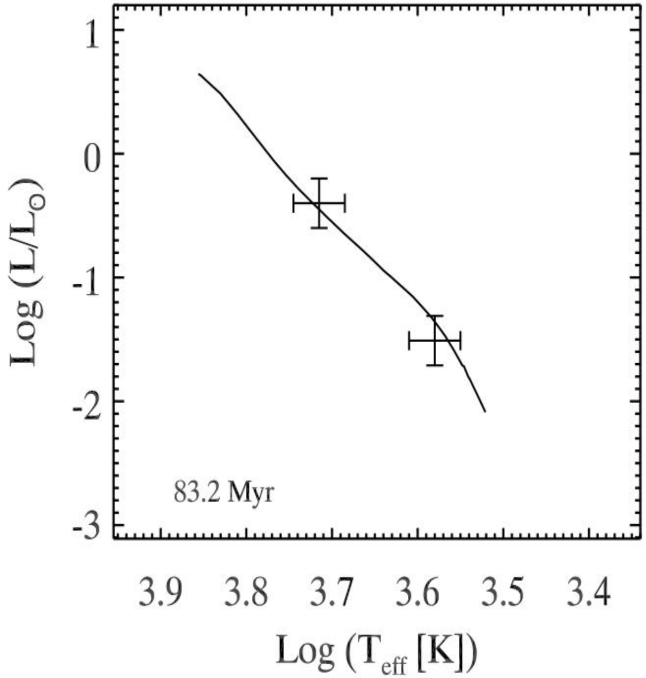
Palla & Stahler
M_1=0.83 $M_☼$
M_2=0.43 $M_☼$
not coeval
t=50 and 100Myr

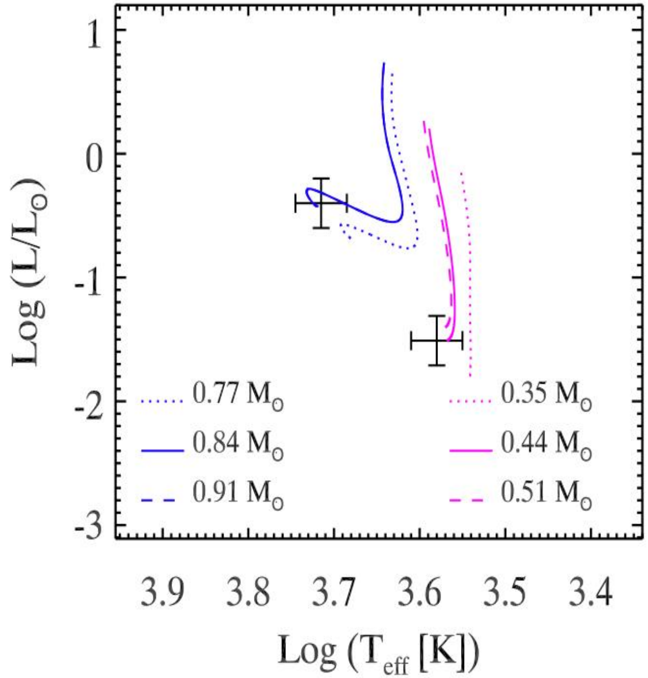
Baraffe
M_1=0.93 $M_☼$
M_2=0.50 $M_☼$
coeval
t=100-150Myr



M_1=0.96±0.09 $M_☼$
M_2=0.56±0.05 $M_☼$

…2 hours ago results





Gennaro, Prada Moroni & Tognelli (see poster n.3)

I.Testing evolutionary tracks of PMS stars: results

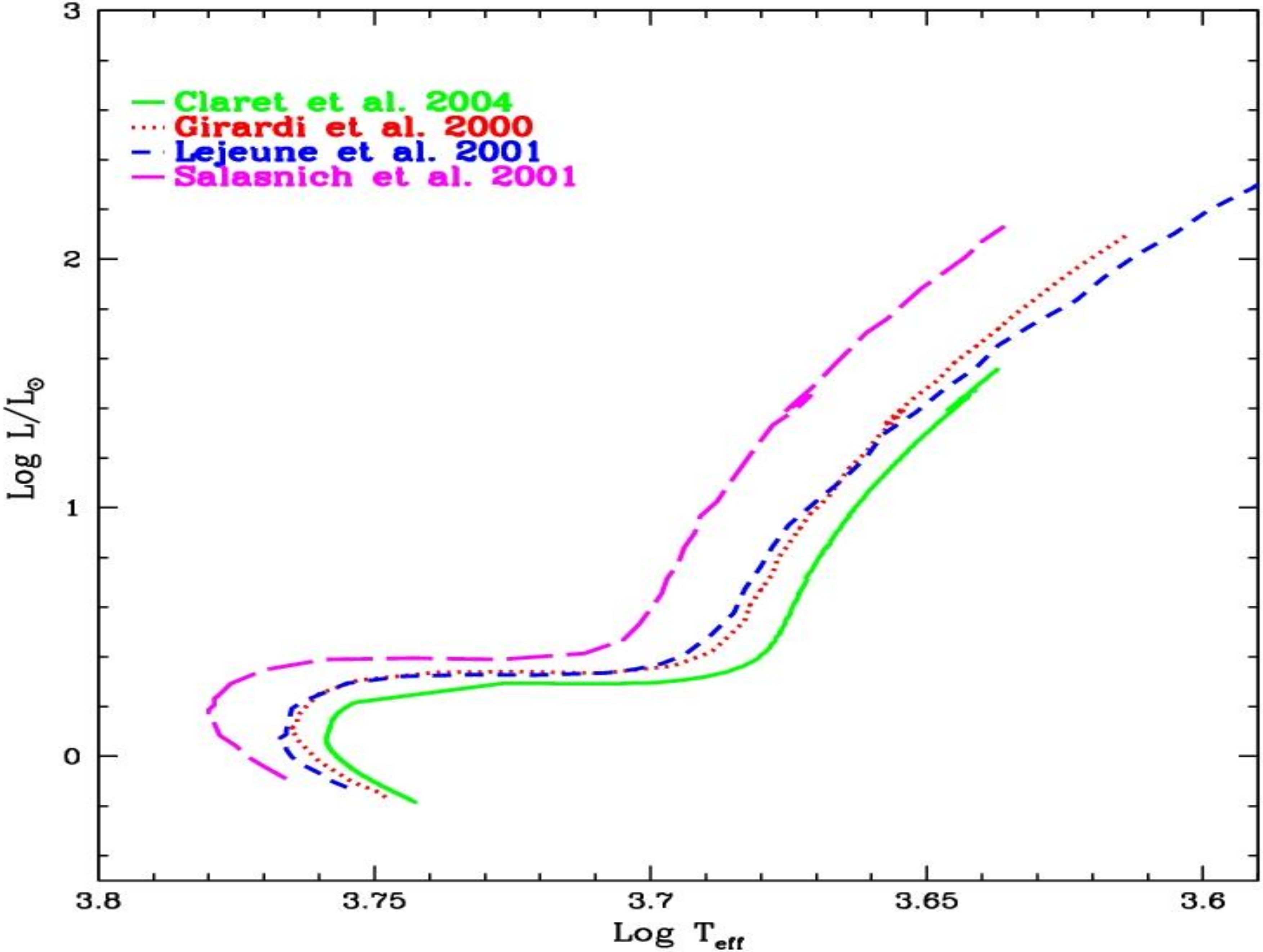
- Sample of 13 young binaries suitable for observation with Optical Interferometers
- Dynamical mass of the HD113449 components using HARPS+CRIRES+AMBER
- Baraffe tracks fit better the masses of HD113449 agreement with Hillenbrand & White (2004) for tracks in the range 0.5-1 $M_{\odot}$

II.Testing evolutionary tracks of giant stars:why?

- Same problematic of PMS tracks, the models differ depending on the author

- To study the correlation between mass of the host star and the planet

- Giants offer the possibility to find planet around massive star – 31 planets hosting giant stars known in literature



Claret et al. 2004
Girardi et al. 2000
Lejeune et al. 2001
Salasnich et al. 2001
Log L/L$_\odot$
Log T$_{eff}$
3
2
1
0
3.8
3.75
3.7
3.65
3.6

II.Testing evolutionary tracks of giant stars:methods

- Measure the diameters of a sample of giant stars – 30 giants observed (7 hosting planets) with CHARA array and VLTI
- Time series observations with high resolution spectrographs – primary frequency splitting or/and frequency of maximum amplitude oscillations – ongoing

  HD170693 started@TLS
- $D + \Delta\nu$ or $D + T_{eff} + \nu_{max} \longrightarrow$ Mass

  (Kjeldsen & Bedding 1995)

Interferometric observations

Northen sample: (Baines et al. 2010)

25 giants observed with “CHARA classic” beam combiner@CHARA array

2.15 μm

Southern sample: (Cusano et al. in preparation)

5 giants observed with AMBER@VLTI (ATs)

11 spectral channels H band

17 spectral channels K band

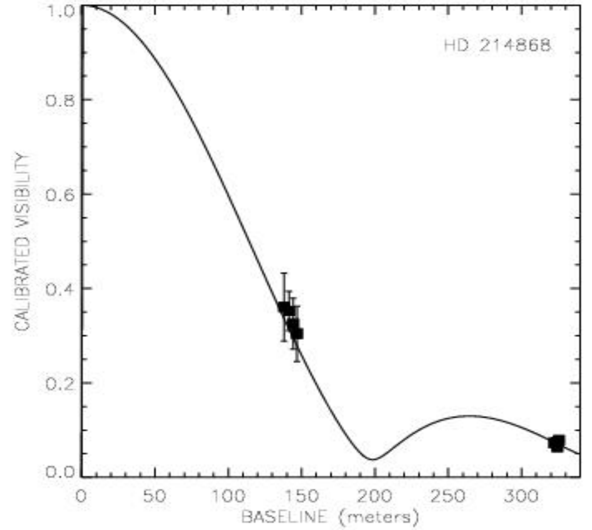
Interferometric diameters

- Northern sample:

  Limb-darkened models

$$V = \left(\frac{1-\mu_\lambda}{2} + \frac{\mu_\lambda}{3}\right)^{-1} \left[(1-\mu_\lambda)\frac{J_1(\frac{\pi B\theta}{\lambda})}{\frac{\pi B\theta}{\lambda}} + \mu_\lambda \left(\frac{\pi}{2}\right)^{1/2} + \frac{J_{3/2}(\frac{\pi B\theta}{\lambda})}{(\frac{\pi B\theta}{\lambda})^{3/2}}\right]$$

Baines et al. 2010

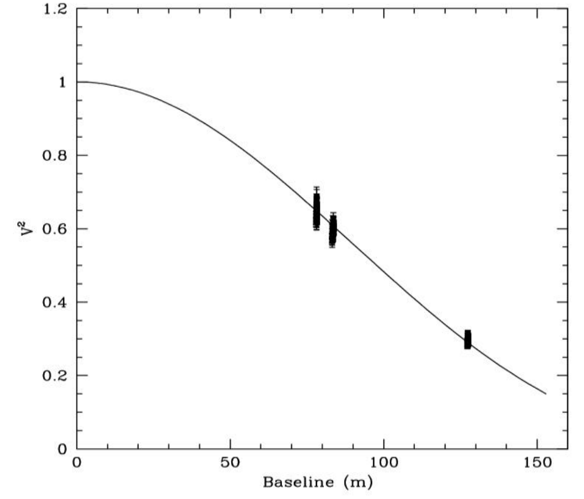


- Southern sample:

  UD models   H & K bands

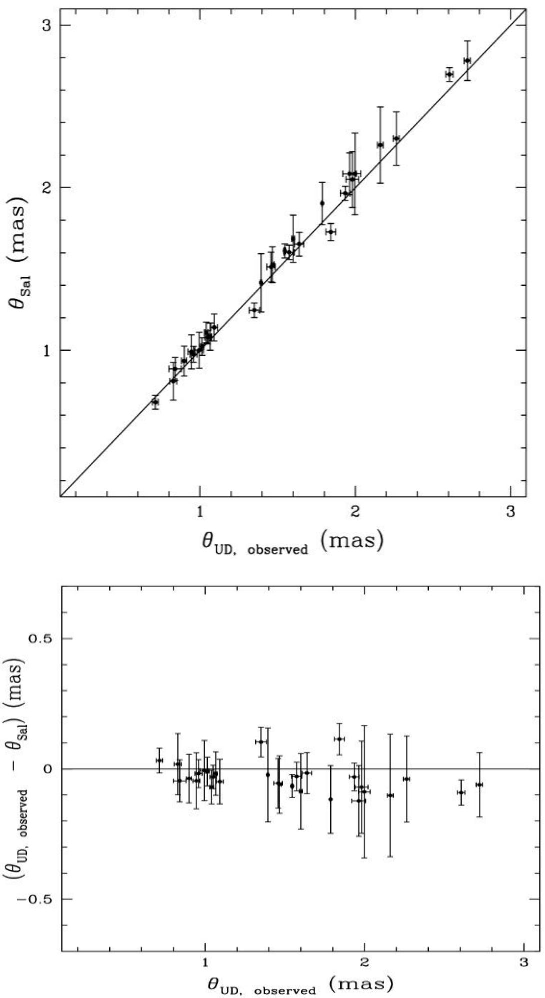
$$V(\theta) = \frac{2J_1(\frac{\pi B\theta}{\lambda})}{\frac{\pi B\theta}{\lambda}}$$

Cusano et al. in preparation

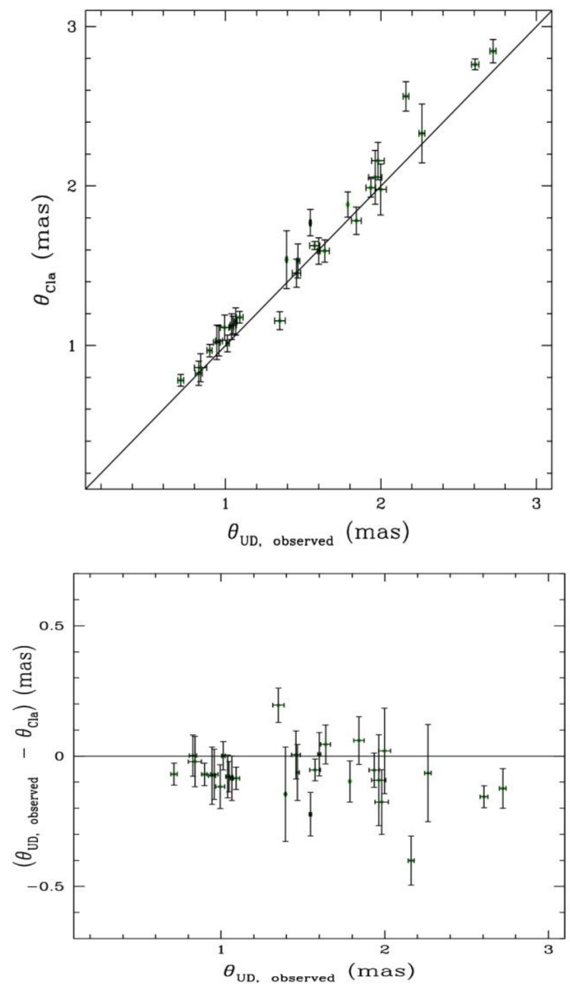


First test: angular diameters comparison

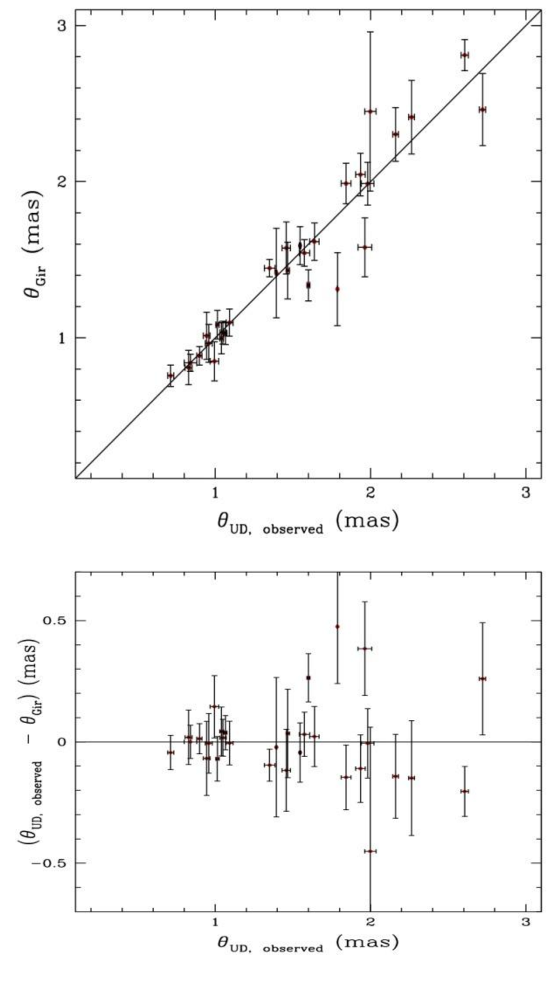
Salasnich et al. 2001



Claret et al. 2004



Girardi et al. 2000



Temperatures

- Using the diameters is possible to derive the effective temperature through:

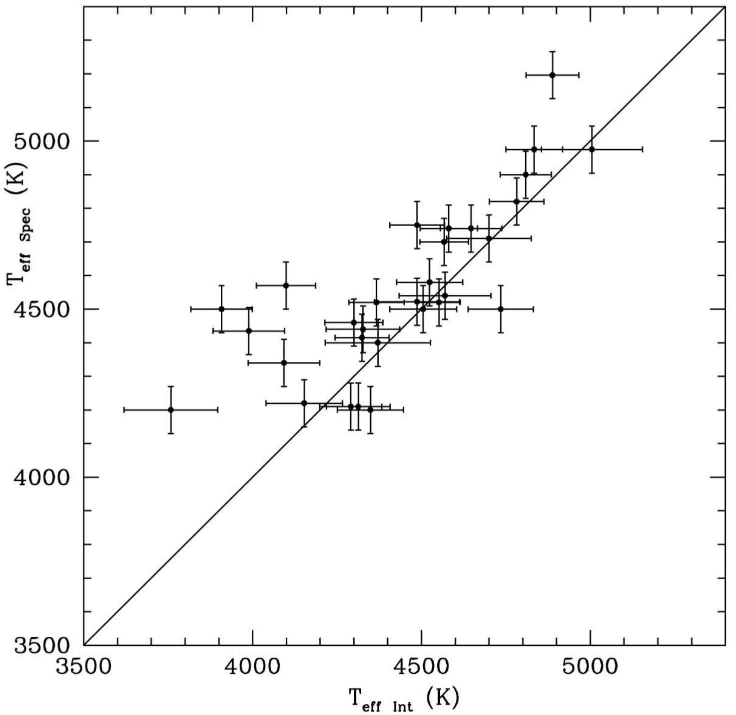
$$F_{bol} = \frac{1}{4}\theta_{LD}^2 \sigma T_{eff}^4$$

Extinction curve

(Cardelli et al.1989)

Bolometric corrections

(Alonso et al. 1999)

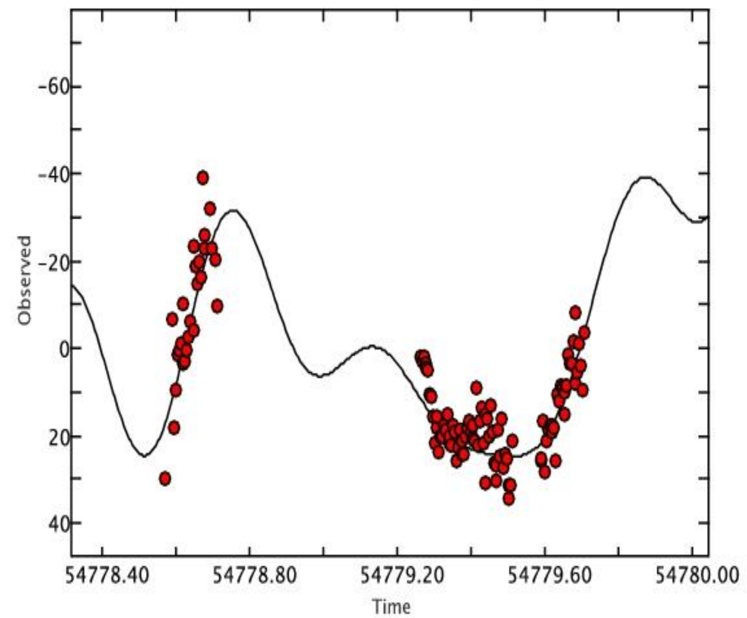


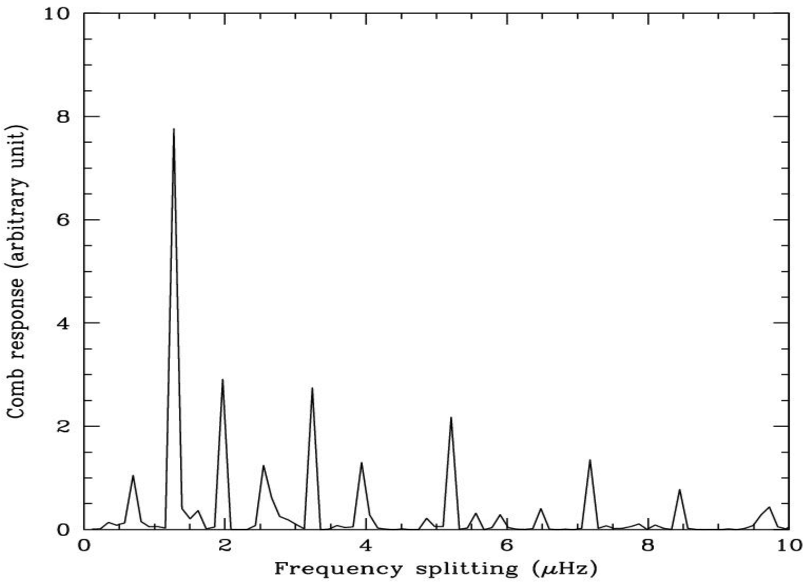
Oscillations of the K giant HD170693

Hosts a planet with P=479 days
(Döllinger et al. 2009)

25 hours of observations with
high resolution echelle spectrograph @ TLS

RADIAL to measure RV (Hatzes et al. 2000)





ν_{max}=8.75±0.13 μHz

$\Delta\nu$≈1.28 μHz

Mass of HD170693

Kjeldsen & Bedding 1995

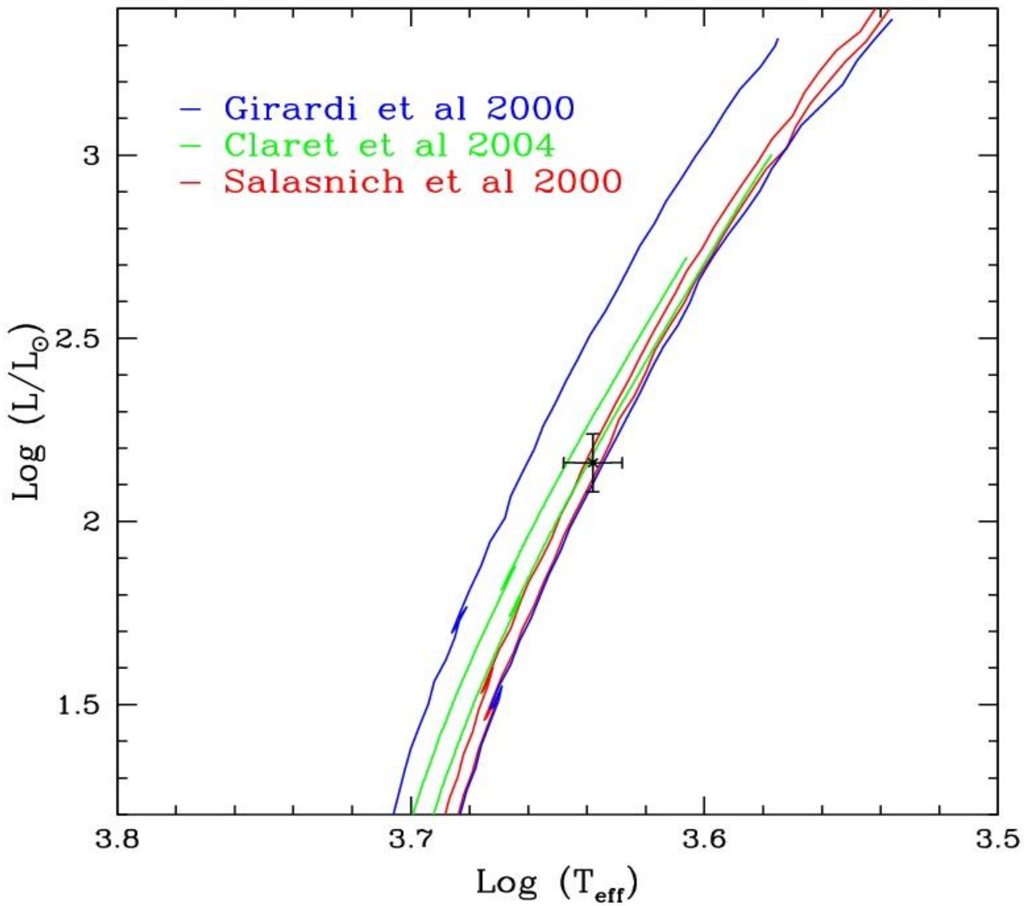
$$M/M_{\odot} = \Delta\nu_0^2 (R/R_{\odot})^3 134.9^{-2} \mu\mathrm{Hz}$$

$$M/M_{\odot} = \nu_{\max} (R/R_{\odot})^2 \sqrt{T_{\mathrm{eff}}/5777\ \mathrm{K}}\ 3.05^{-1} \mathrm{mHz}$$

M=1.01±0.10 $M_{☼}$

From the tracks

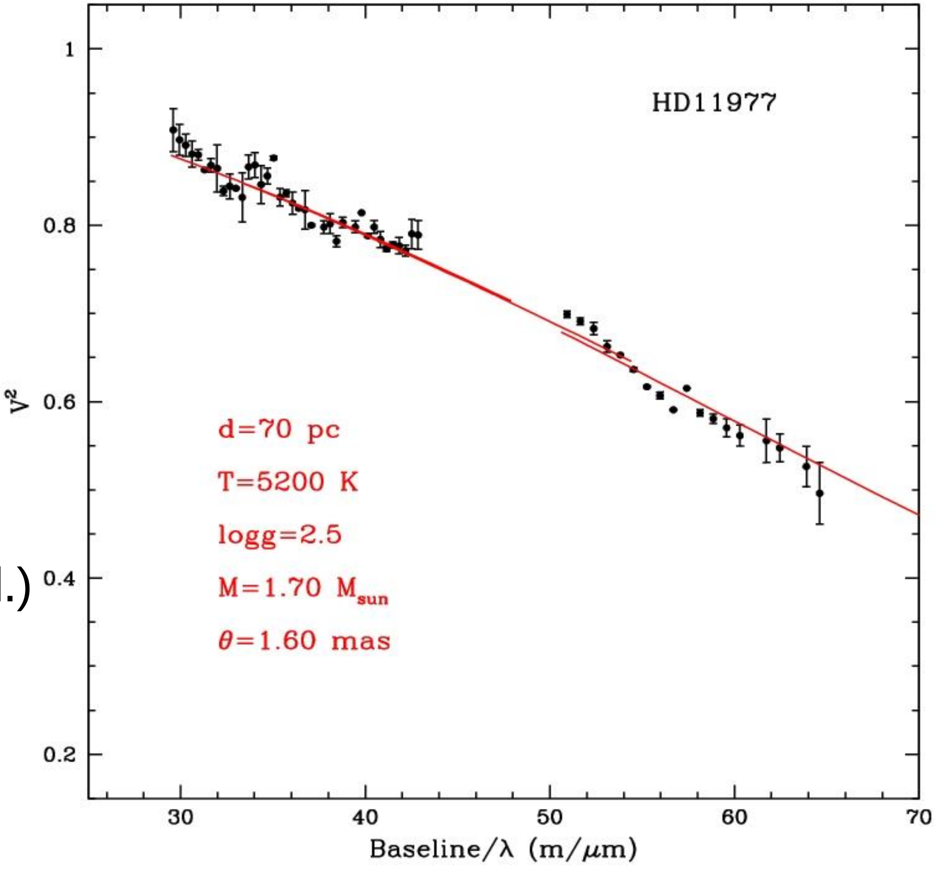
M_{sal}=1.00±0.10 $M_{☼}$
M_{gir}=0.98±0.05 $M_{☼}$
M_{cla}=1.00±0.11 $M_{☼}$



Comparison with visibility profiles: the case of HD11977

- MARCS model atmospheres
  Aringer et al. 2009
- Visibility profiles
  Paladini et al. private c.

d =67.1±0.7 pc (van Leeuwen 2007)
T_{eff}=4975 K (da Silva et al. 2006)
Log(g) =2.66
M=1.86 ±0.30 $M_{¤}$
Θ=1.58 mas UD analysis (Cusano et al.)
hosts a planet (Setiawan et al. 2005)
P=711 days
M_2 sini=6.54 M_{jup}

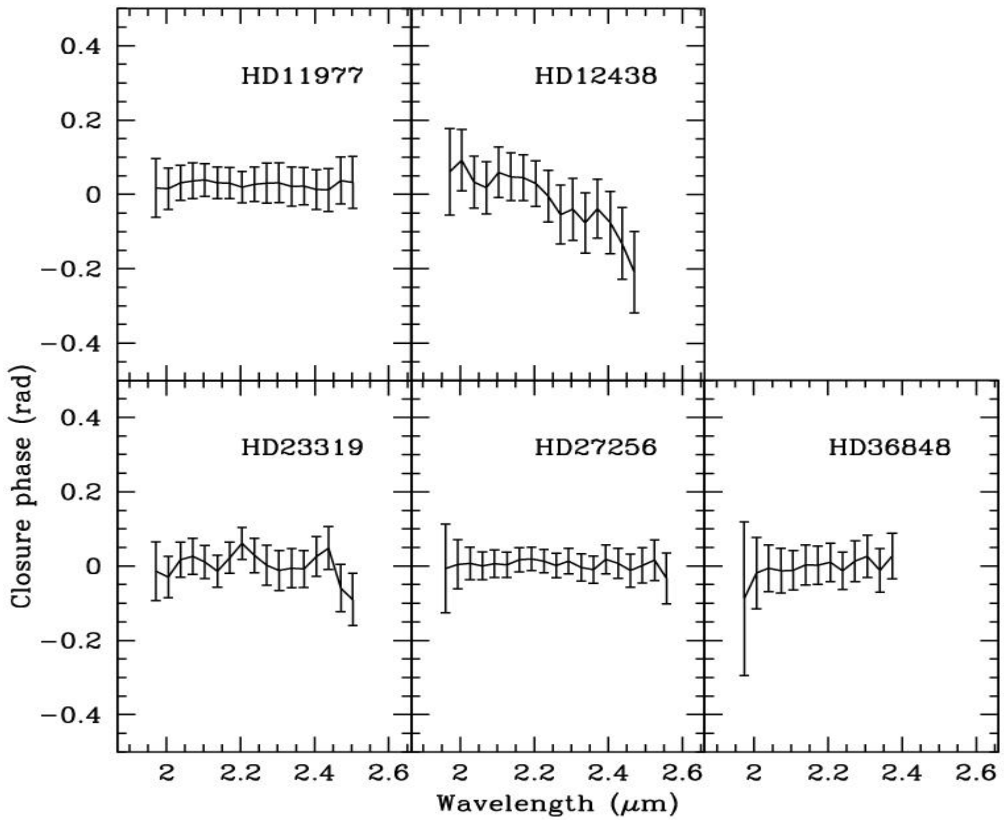


Discovery of a binary: HD12438

Observed with AMBER 5 nights October-December 2008

ρ=6.0±1.5 mas
p.a.=140±20°
f ≈0.03
θ_1=1.00±0.10 mas
θ_2< 0.30 mas

RVs in literature
From Setiawan et al. 2004
Döllinger private com.
Show a linear trend P >9.5 yrs



II.Testing evolutionary tracks of giant stars: results

- interferometrically diameters of 30 giant stars with precision up to < 1%
- First test with diameters – Salasnich et al. tracks fit better the observations
- Difference between T_{eff} spec and T_{eff} interferometric expecially at low temperature
- Mass determination of HD170693 Int+Osc

  consistent with models
- HD11977: obs vs. profiles gives physical parameters
- Discovery of the binary HD12438


Tschuess
Ciao
Bye
felix.cat.79@hotmail.it
Special thanks:
Eike, Artie, Michael,
Davide,Bringfried

Eclipsing binaries

- 10 masses so far determined with good accuracy

☺: the radii are also measured together with effective temperature ratio

☹: they are rare; the components are usually very near and **they are exchanging mass**

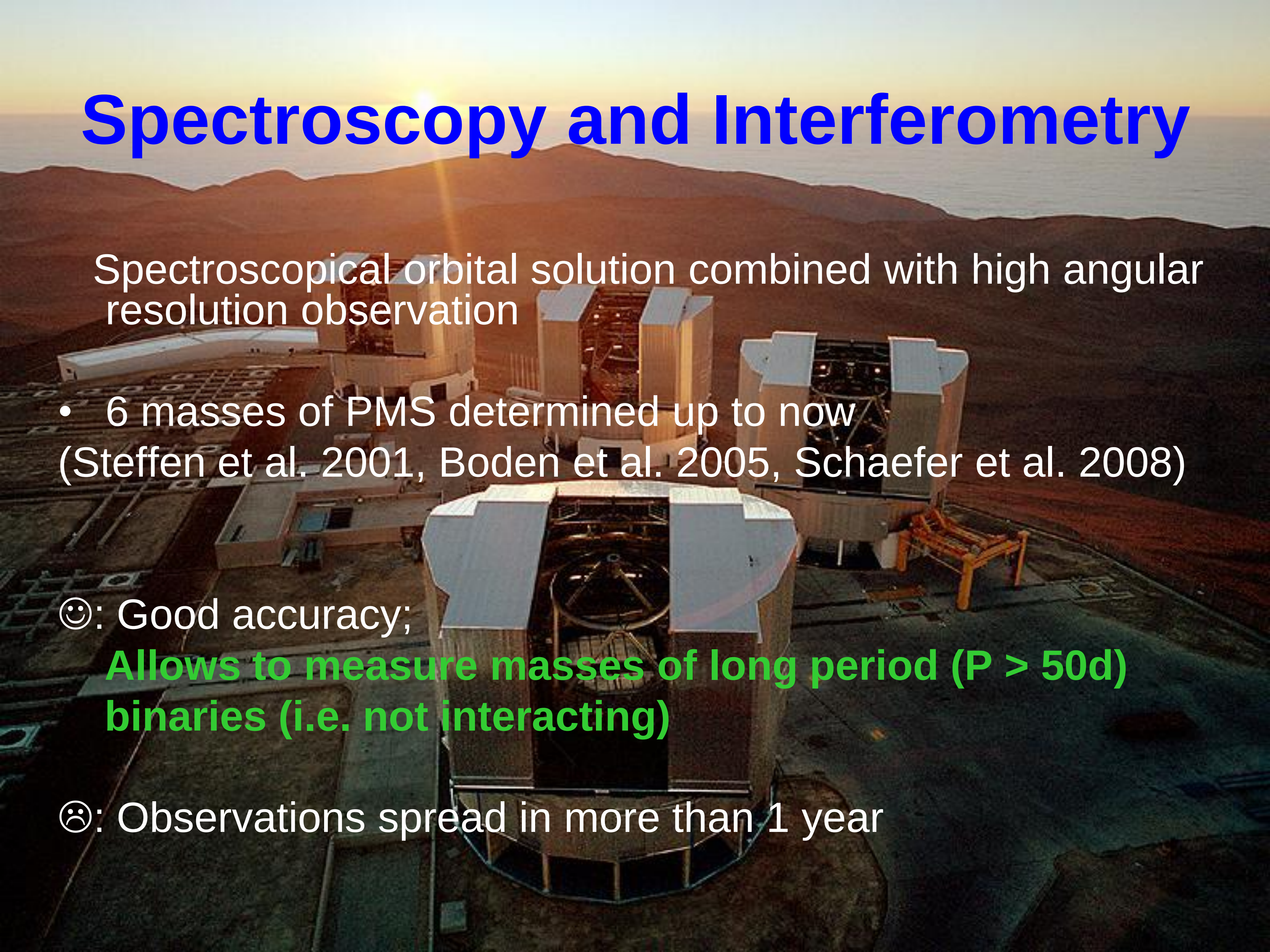
e.g. Stassun et al. (2008) found two "identical twins" (same masses to within 2%) with 300K difference in temperature and 50% difference in luminosity

Disk Kinematics

- 9 masses measured

☺: Rotation of disks measured via mm interferometry in CO lines
(Simon et al. 2000)

☹: Low accuracy in the mass determination (~15-20%)



Spectroscopy and Interferometry

Spectroscopical orbital solution combined with high angular resolution observation

- 6 masses of PMS determined up to now

(Steffen et al. 2001, Boden et al. 2005, Schaefer et al. 2008)

☺: Good accuracy;

Allows to measure masses of long period (P > 50d) binaries (i.e. not interacting)

☹: Observations spread in more than 1 year

Dynamical masses of PMS

- Eclipsing binaries (P < 10 d)
- Disk kinematics
- Spectroscopy and Interferometry (P >100d)

Our project

Measure dynamical masses of stars in binary systems using S+NIR Interferometry

1° step

Spectroscopic survey on more than 100 young stars to search for binaries

2° step

Determination of the spectroscopic orbit and collection of a sample of 14 young binaries with period > 50 days

(exchanges of mass avoided) Guenther et al. 2007

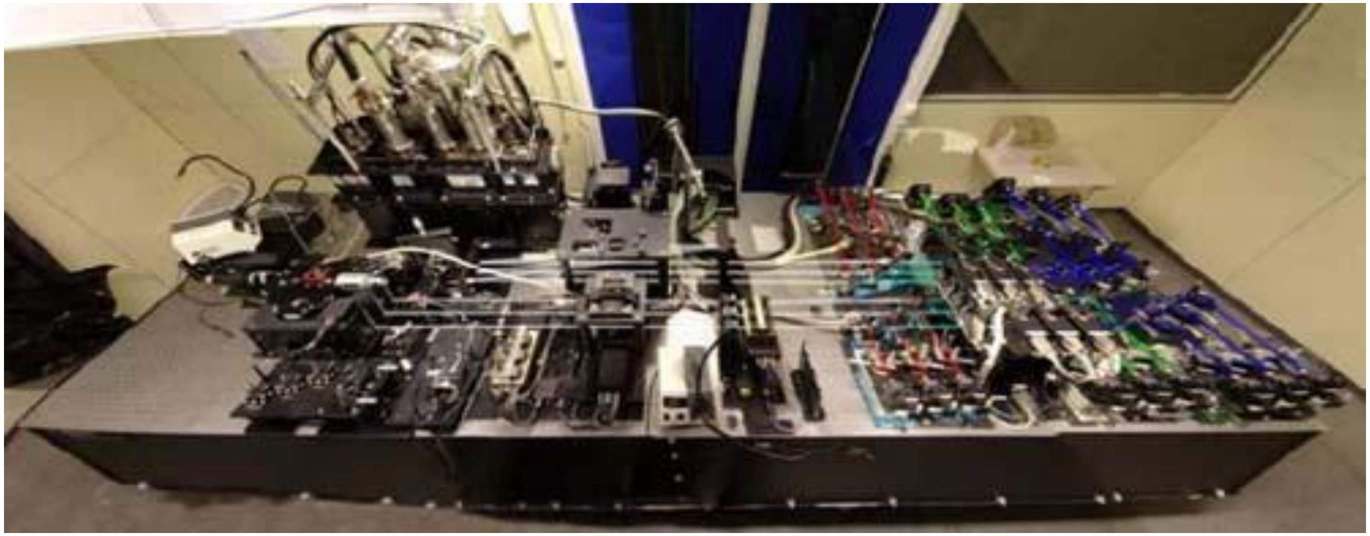
Short period binaries are active connected
(e.g. RX J1603.8-3938 P~8d same masses but different luminosities, Guenther et al. 2001)

3° step

Observing the binaries with AMBER@VLTI

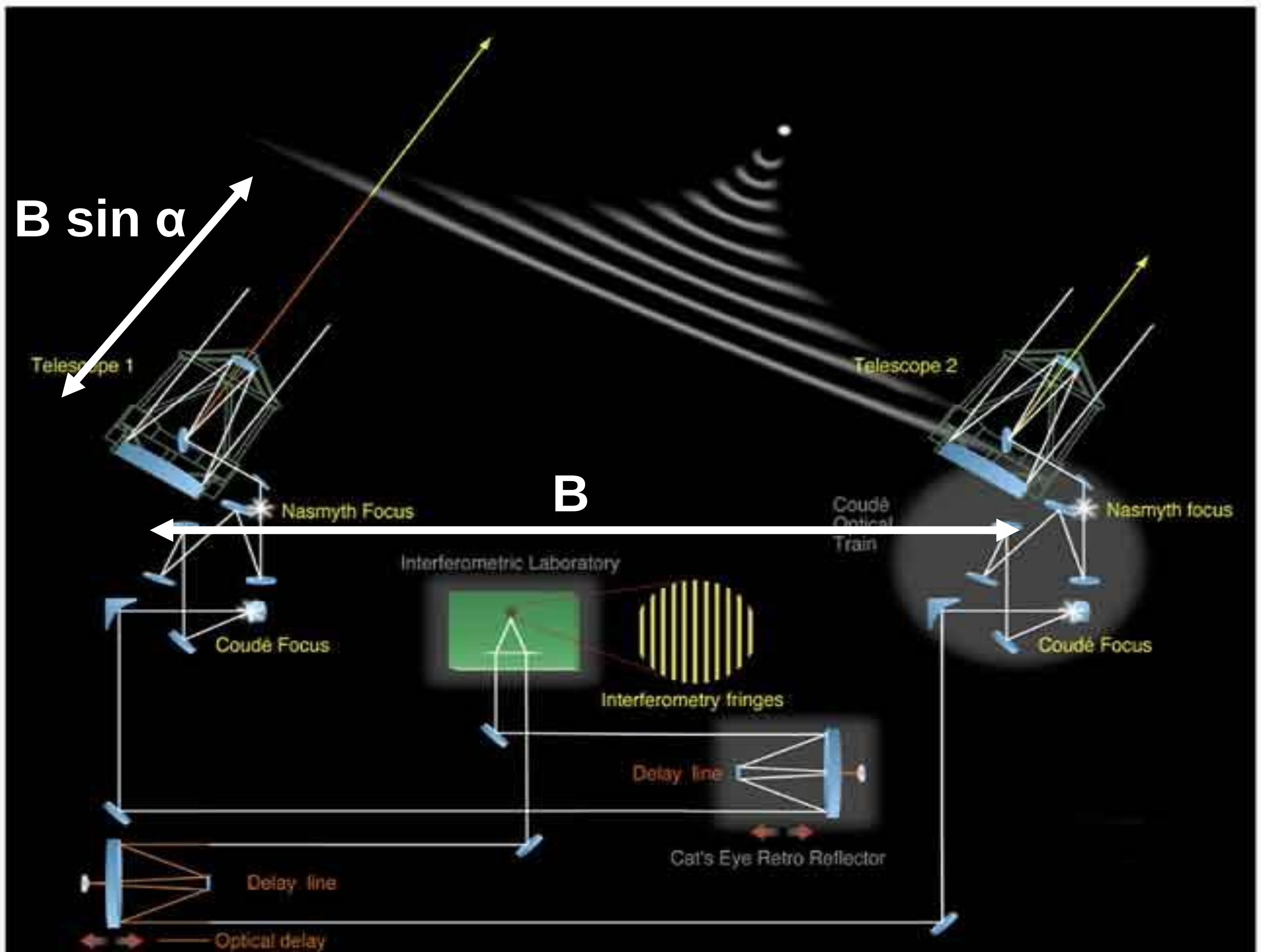
What is AMBER?
(Astronomical Multi-BEam combineR)

Focal instrument of the VLTI that combines the light coming from two/three UTs/ATs giving spectral dispersed fringes in the J, H and K bands



Basic principles for VLTI interferometry

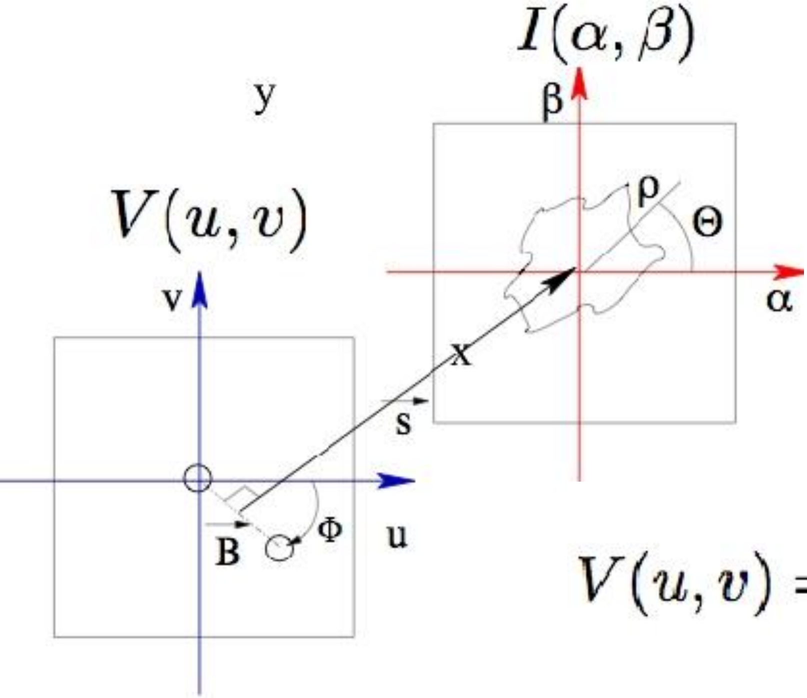
- **Young's double-slit experiment**



- $V = |V|\, e^{-i\varphi}$
- $|V| = \dfrac{I_{max} - I_{min}}{I_{max} + I_{min}}$
- φ = distance between the maximum of the fringe and the zero OPD (optical path delay)

Van Citter-Zernike theorem

- The Fourier transform of the brighteness distribution of a source in the sky is equal to its complex visibility



Spatial frequency coordinates:

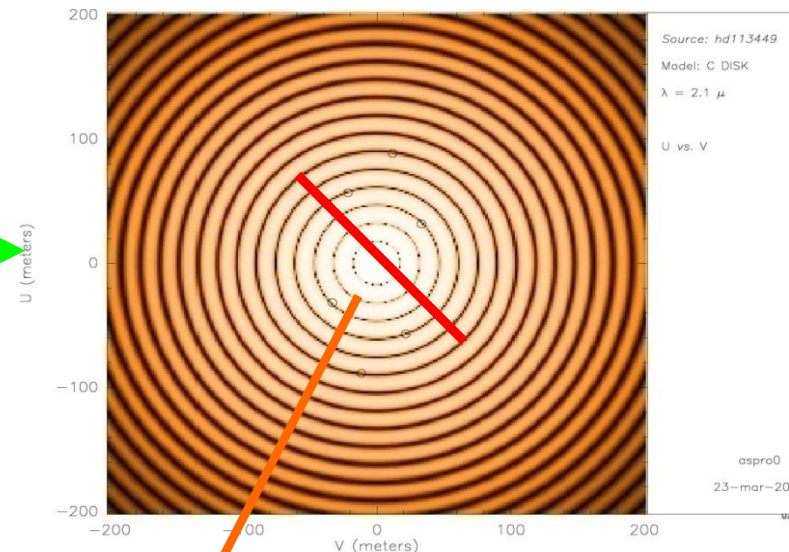
$u = B_{px}/\lambda$ $v = B_{py}/\lambda$

Bx and By are the projected baselines coordinates onto the sky, i.e. the baseline as seen from the star

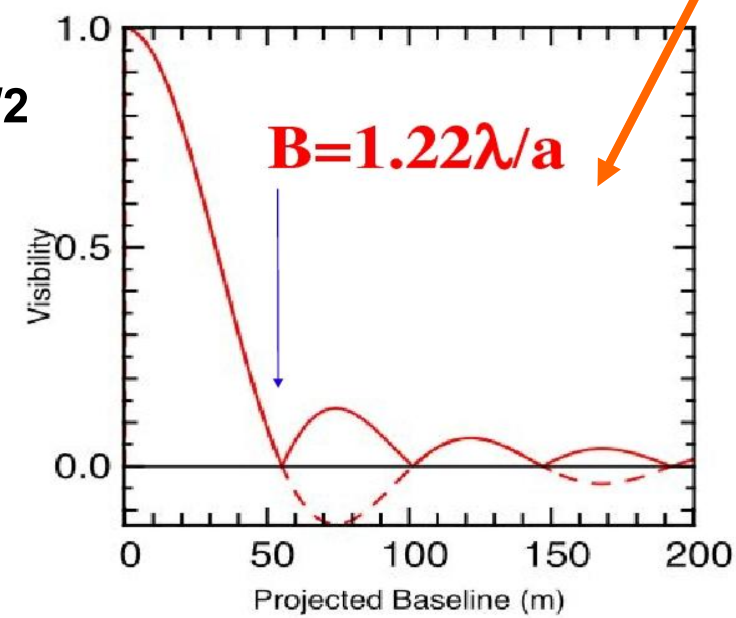
$$V(u,v) = \frac{\int\int I(\alpha,\beta)\exp^{-2i\pi(\alpha u+\beta v)}\, d\alpha d\beta}{\int\int I(\alpha,\beta) d\alpha d\beta}$$

From the sky to the UV plane
Star diameter (constant disk)

FT



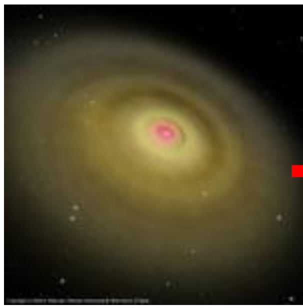
$I(r) = 4/(\pi a^2)$ if $r=(x^2+y^2)^{1/2} \leq a/2$
$I(r) = 0$ otherwise
a=angular diameter



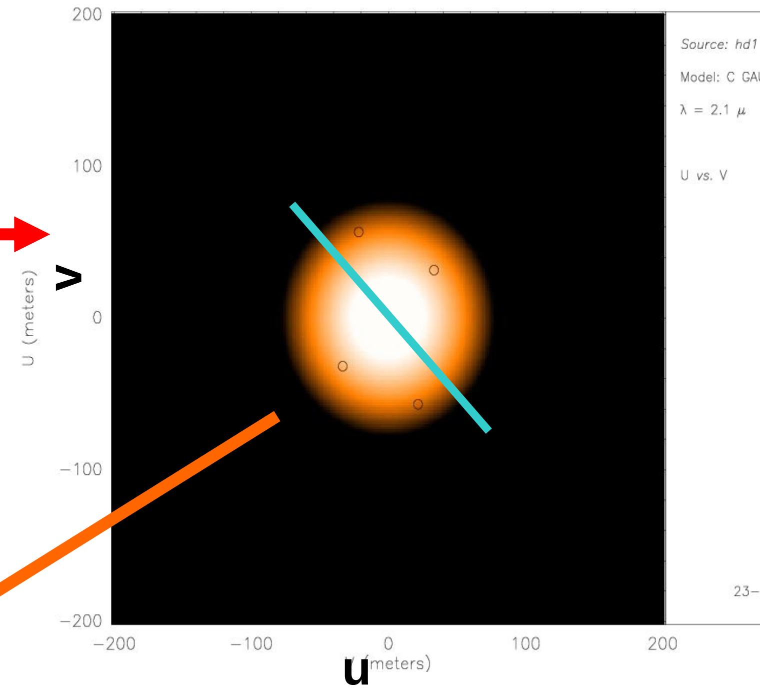
$$V(\rho)= \frac{J_1(\pi a\rho)}{\pi a\rho}$$

with $\rho=(u^2+v^2)^{1/2}$

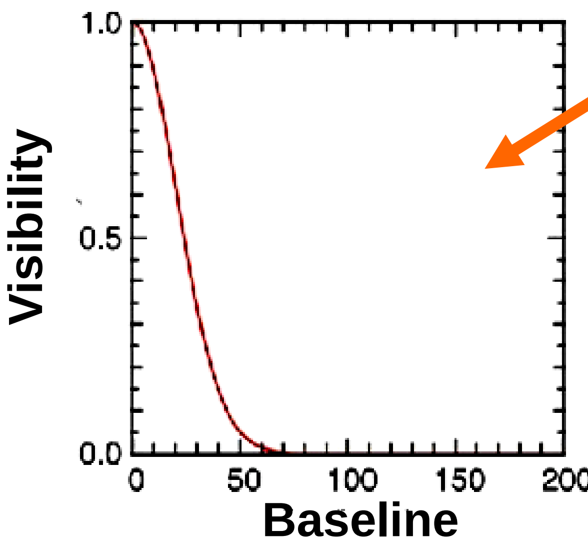
From the sky to the UV plane
Circumstellar disk (Gaussian disk)



FT



$$I(r) = \frac{I_0}{\sqrt{\pi/4\ln 2a}} \exp(-4\ln 2r^2/a^2)$$



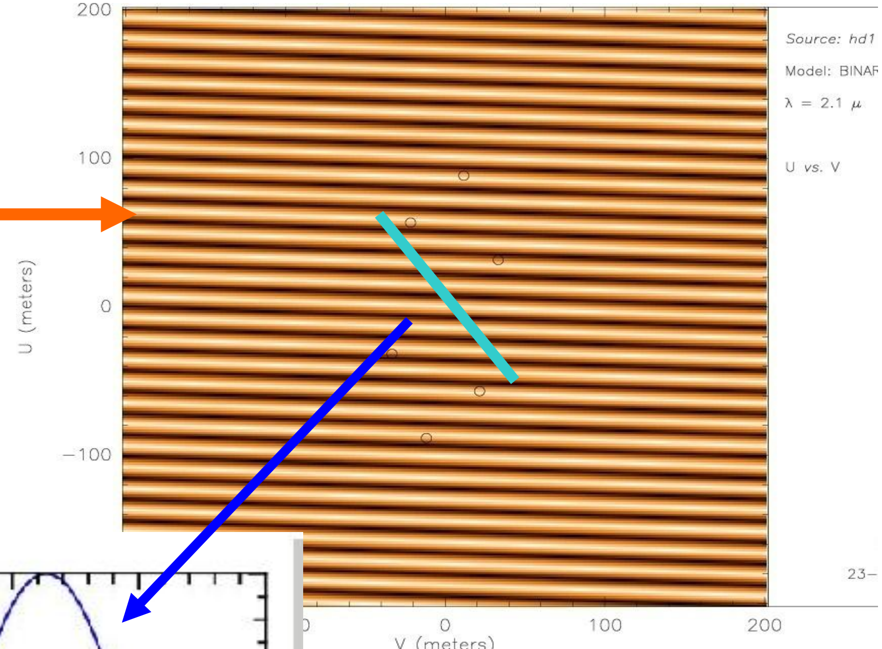
$$V(\rho) = \exp[-(\pi a \rho)^2/(4\ln 2)]$$

$\rho^2 = u^2+v^2$

a=FWHM

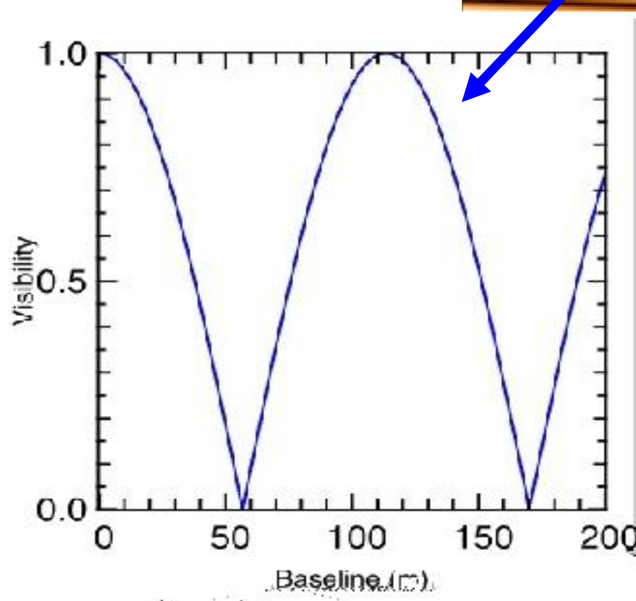
From the sky to the UV plane
Binary

FT



$I(l,m)=I_1\boxtimes(l-\beta/2)\boxtimes(m)+I_2\boxtimes(l+\beta/2)\boxtimes(m)$

β= angle separation



V=(1+f²+2fcos(2✍B̄•β̄/✍))^1/2 / (1+f)

$$V=\frac{(1+f^2+2f\cos(2\,✍\,\bar{B}\bullet\bar{\beta}/✍))^{1/2}}{(1+f)}$$

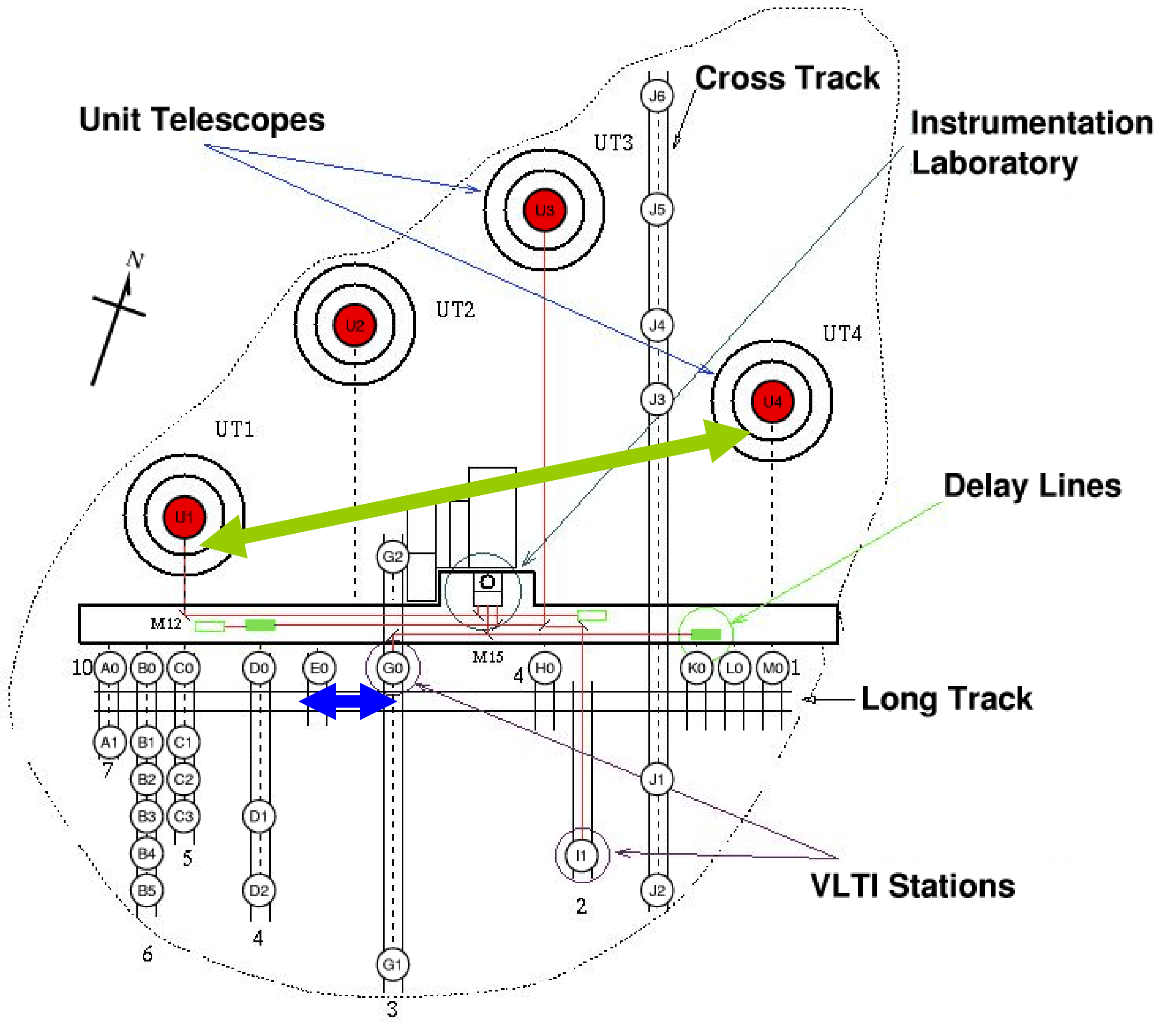
f=flux ratio
$\bar{B}$=baseline vector
$\bar{\beta}$=separation vector

The VLTI stations

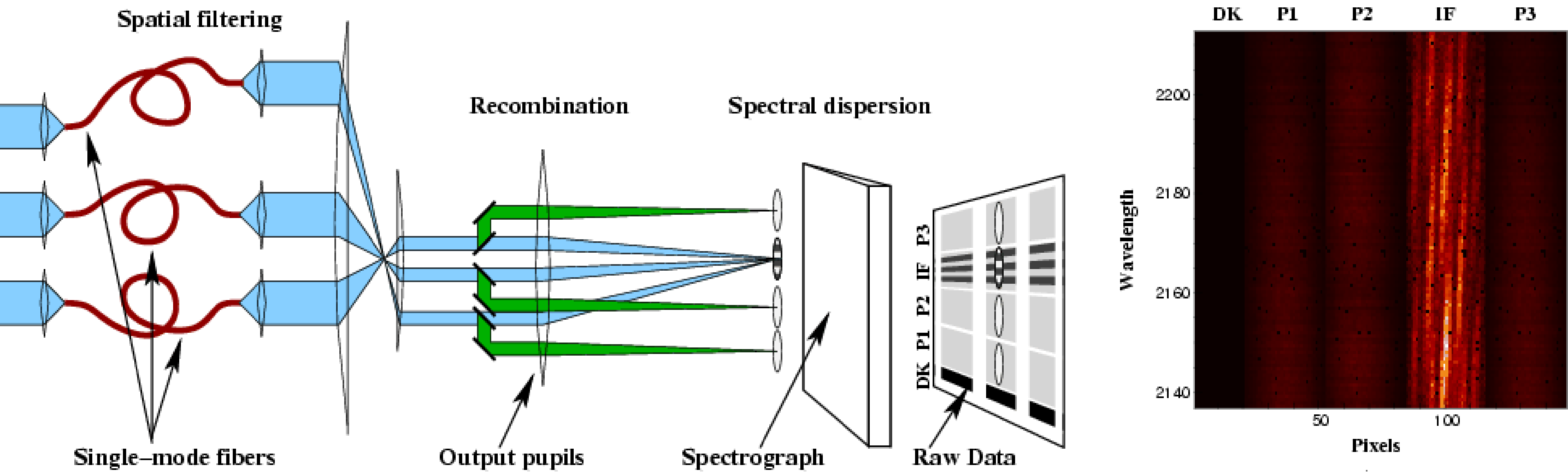
4 different triples with UTs and 4 with ATs available last ESO semester for AMBER

minB (E0-G0)=16m

maxB (UT1-UT4)=130m



How does AMBER work?



•The light coming from three telescopes is injected in the fiber

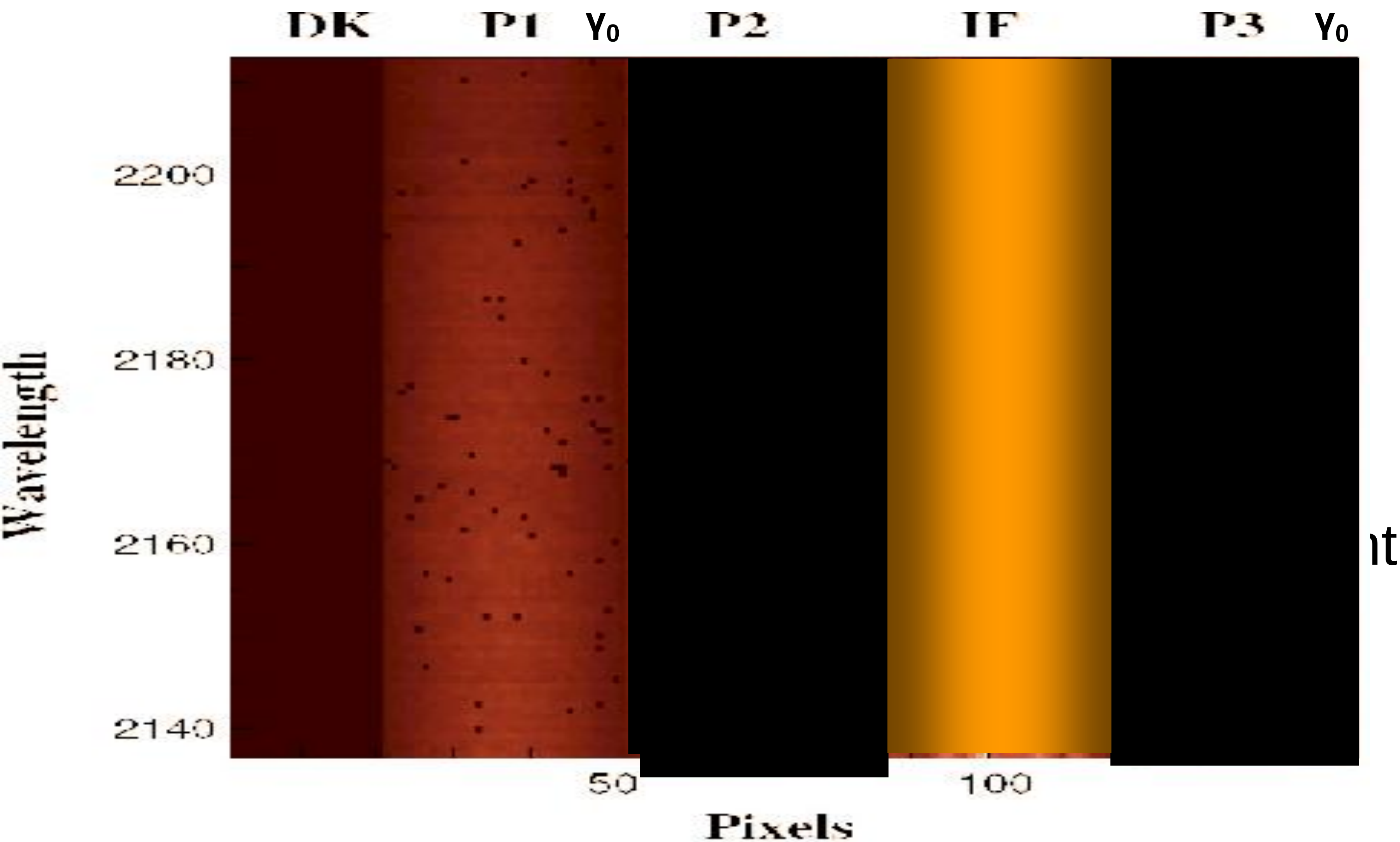
•Spatial filtering (phase fluctuation of the wavefront convert in intesity variation)

•Separation in three photometric channels and in one for interference

•Spectral dispersion (LR, MR and HR)

•Detector

How does AMBER work?



How does AMBER work?

$$\frac{|V^{ij}|^2}{V^{ij2}_c} = \frac{\langle R^{ij2} + I^{ij2}\rangle - \mathrm{Bias}\{R^{ij2} + I^{ij2}\}}{4\langle P^i P^j\rangle \Sigma_k v^i_k v^j_k}$$

$|V^{ij}|^2$ =squared visibility relative to the ij baseline

V^{ij2}_c=visibility of internal calibration source

$v^i_k P^i$=photometric component per pixel k

the measure is weighted by the visibility of the internal source → atmospheric calibration necessary to delete this term

Our project (with today AMBER)

”….. The magnitude limit of AMBER is expected to reach *K=20* when a bright reference star is available and ***K=14*** otherwhise….”(AMBER consortium web page 2000)

Today :“….On the UTs it is possible to reach **H=7**. On the AT's, the limiting magnitude is H=5…” (ESO web page 2008)

Table 1. Spectroscopic binaries with periods longer than 50 days.

	This survey/ region	*EW* Hα	*EW* LiI [Å][1]	Spec type [Å]	m_K type	RA [mag]	Dec (2000.0)	Type (2000.0)	Period [days]
HIP50796[2]	no / TWA	0.20[3]		K5/WTTS	7.66 ± 0.03	10 22 18.0	−10 32 15	SB1	570
CS Cha	yes / Cha	−40	0.53 ± 0.01	K4/CTTS	8.20 ± 0.03	11 02 26.3	−77 33 36	SB1	≥2482
HD97131[4]	no / TWA			F2	7.70 ± 0.02	11 10 34.2	−30 27 19	ST3	134
RXJ-7539	yes / Cha	fi	0.21 ± 0.06	K2/WTTS	7.93 ± 0.02	12 20 34.4	−75 39 29	SB1	613
MO Lup[5]	yes / Lup	−2.3	0.37 ± 0.02	K7/WTTS	8.64 ± 0.02	15 24 03.5	−32 09 51	ST3	>3000
RXJ1534.1-3916	yes / Lup	abs	0.21 ± 0.02	K1/WTTS	8.55 ± 0.02	15 34 07.4	−39 16 18	SB1	>3000
RXJ1559.2-3814	yes / Lup	−1.4	0.23/0.14	WTTS	9.34 ± 0.03	15 59 16.1	−38 14 42	SB2	474
GSC 06209-00735	yes / SC	0.3	0.37 ± 0.01	K2/WTTS	8.43 ± 0.02	16 08 14.8	−19 08 33	SB1	2045
NTTS160814-1857[6]	no / SC	0.7		K2/WTTS	7.69 ± 0.02	16 11 09.0	−19 04 45	SB1	145
GSC 06213-00306	yes / SC	fi	0.24/0.18	WTTS	7.43 ± 0.02	16 13 18.5	−22 12 48	SB2	167
Haro 1-14c[7]	no / Oph			K3/WTTS	7.78 ± 0.03	16 31 04.4	−24 04 33	SB2	591
NTTS162819-2423s[6]	no / Oph	em		G8/WTTS	7.44 ± 0.02	16 31 20.0	−24 30 04	SB1	89
BS Indi[8]	yes / Tuc	abs	0.18 ± 0.02	K0/WTTS	6.57 ± 0.02	21 20 59.8	−52 28 40	SB1	1222

Observations history

We got AMBER time in ESO period 76,77,79,80,81,82

Target BS Indi:

P76,77: Clouds and/or technical problems

P79: observed but too faint

Target HD113449 (next slide):

P80: observation not done

P81: one observation done(20-21° March 2008!!)

P82: two observations should be done

HD113449

d= 22.12 ± 0.62 pc

H=5.674 ± 0.038 mag

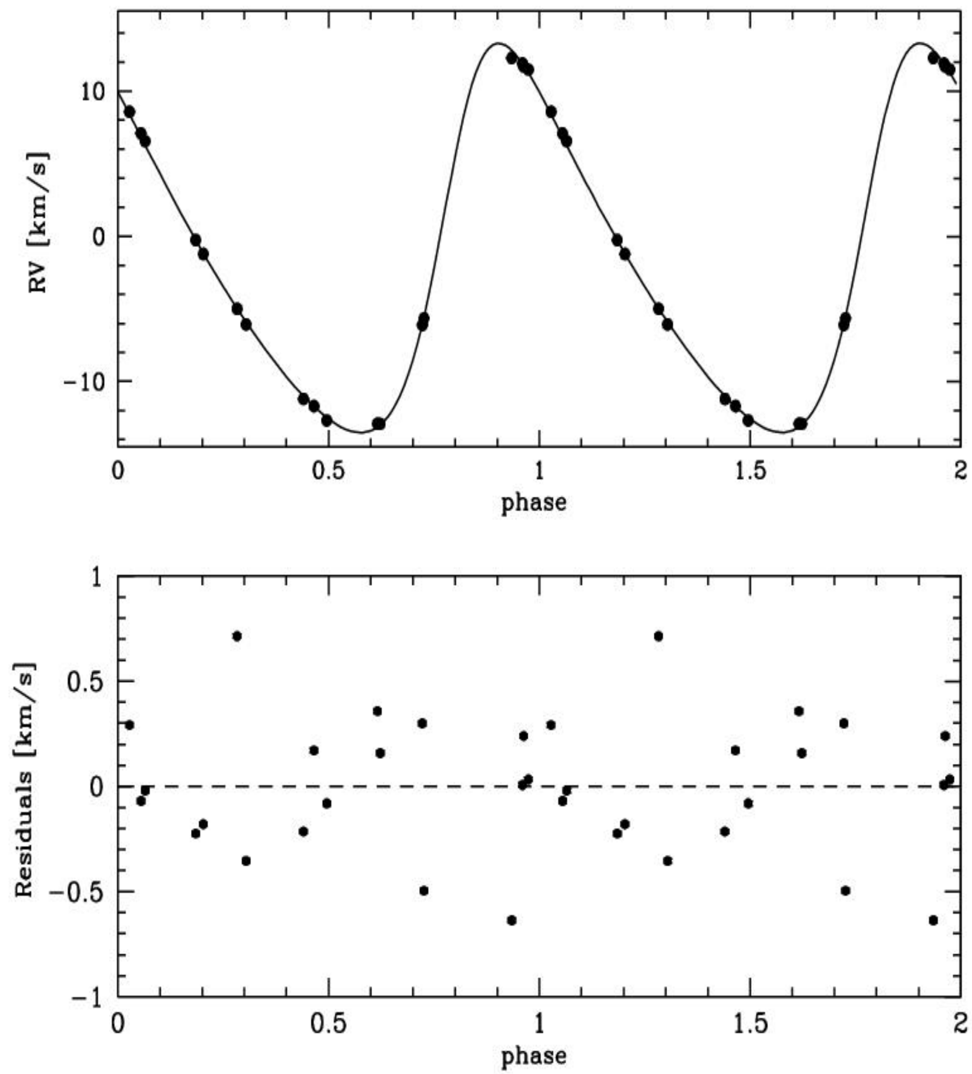
K=5.509 ± 0.023 mag

EW(Li 🖰6708)=0.142 Å

member of AB Dor association
SB1 system found in the
cause of exoplanet-hunting
with HARPS@3.6m in
la Silla

Table 5. Orbital elements HD113449

element	value
P	$216 \pm 0.1\ d$
T_0 [HJD]	2453411 ± 1
γ	$-1.79 \pm 0.02\ km\,s^{-1}$
K_1	$13.40 \pm 0.02\ km\,s^{-1}$
e	0.300 ± 0.005
ω	114.6 ± 0.5^o
$a_1 sin\, i$	0.254 ± 0.001 AU
f(m)	$0.0467 \pm 0.0006\ M_\odot$



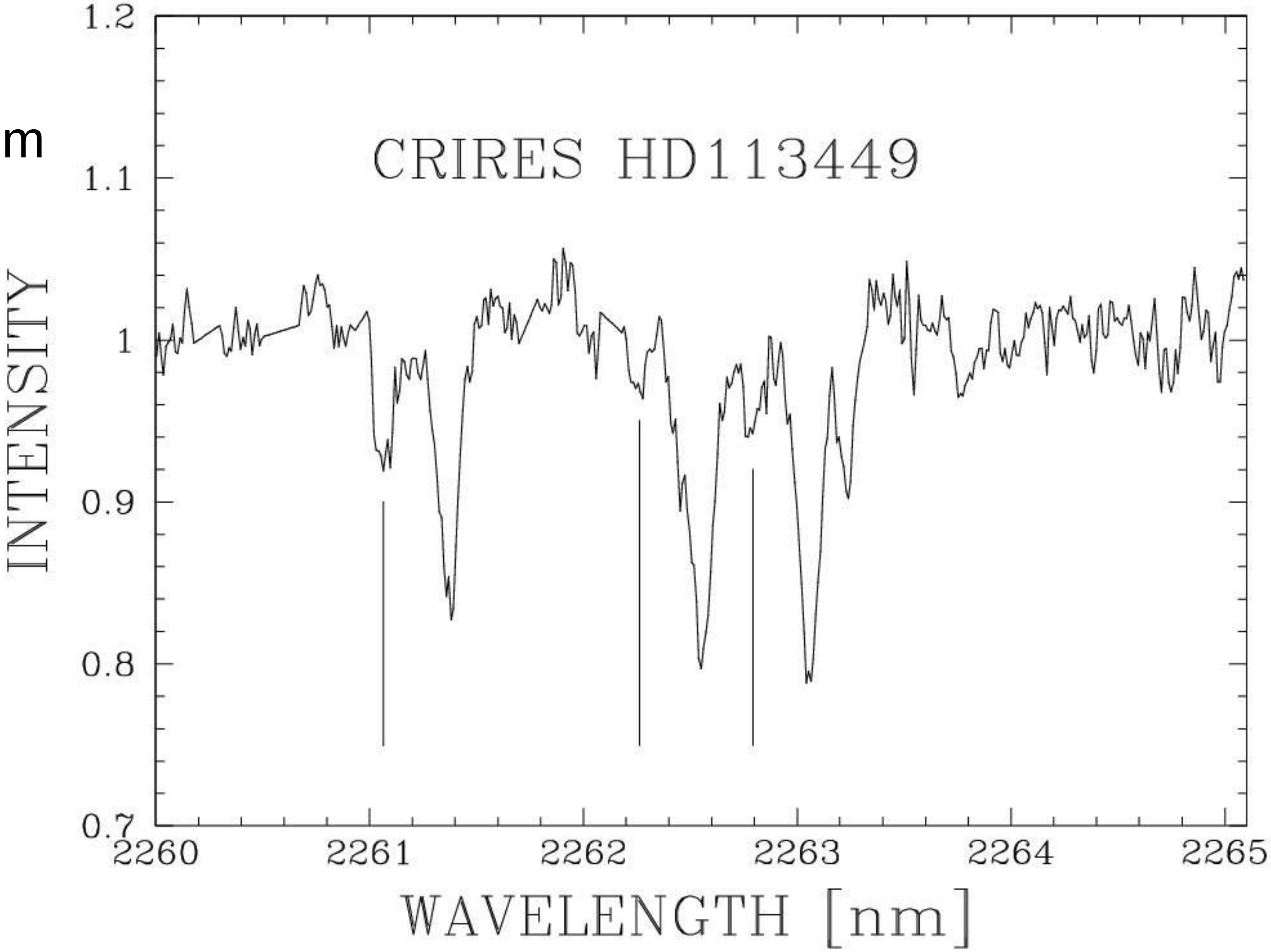
HD113449 observed with CRIRES

R~100000

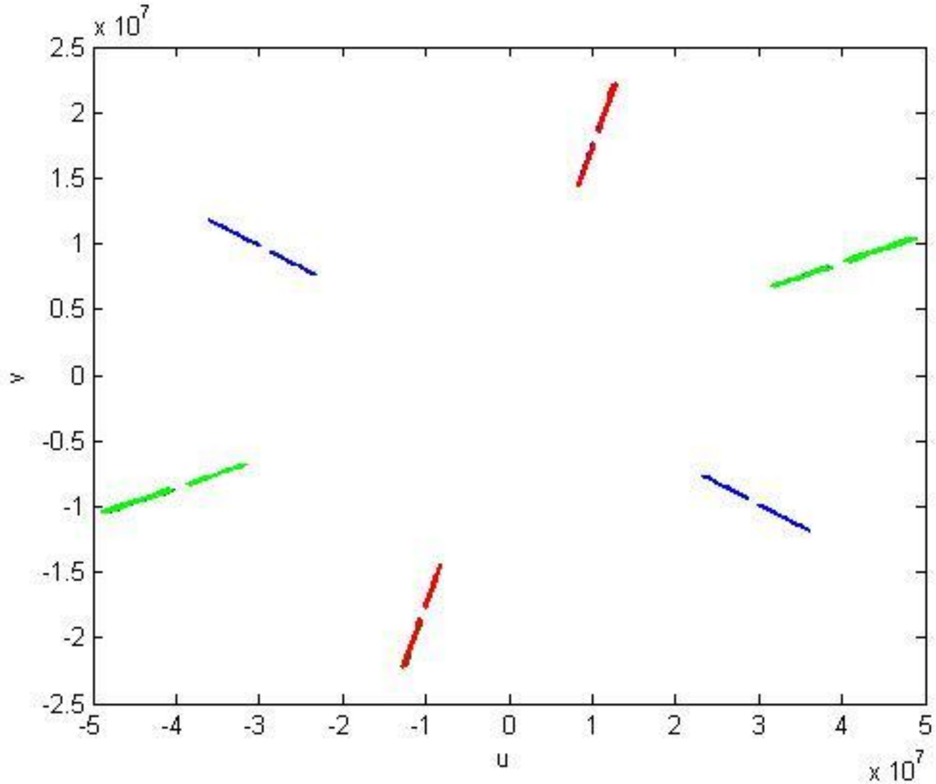
Δλ=2253.97-2304.57 nm

with N_2O cell

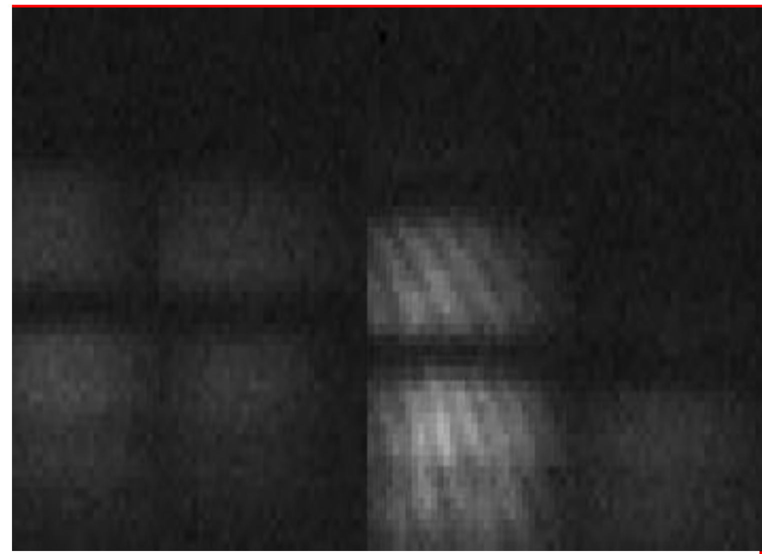
M_2/M_1=0.58±0.03

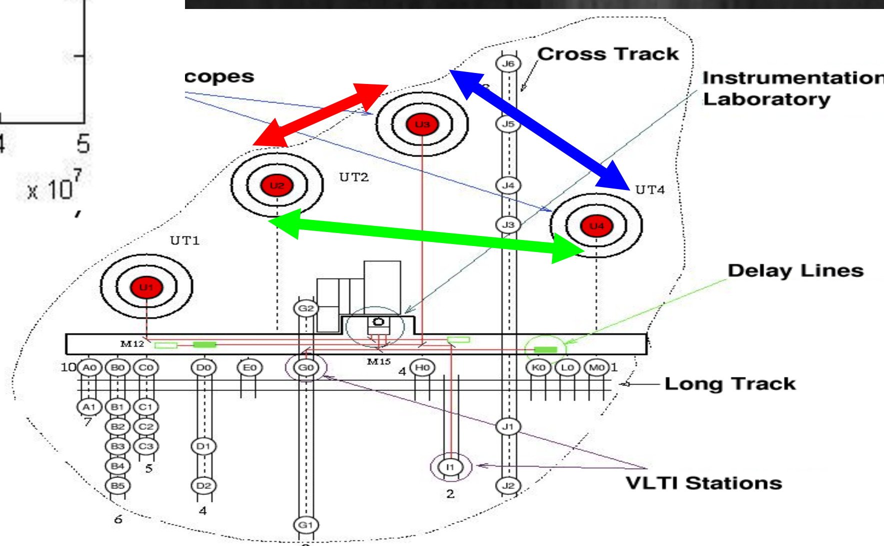


AMBER observation of HD113449



shortly before the
science target





Models

$$V^2 = \frac{1 + f^2 + 2f\cos[2\pi(B_x Ra + B_y Dec)/\lambda]}{(1+f)^2}$$

$Ra = A(\cos E - e) + B(1-e^2)^{1/2} \sin E$

$Dec = C(\cos E - e) + D(1-e^2)^{1/2} \sin E$

$M = 2\pi(t_{obs} - \tau)/P$

$M = E - e\sin E$

$A = a(\cos\omega\cos\Omega - \sin\omega\sin\Omega\cos i)$

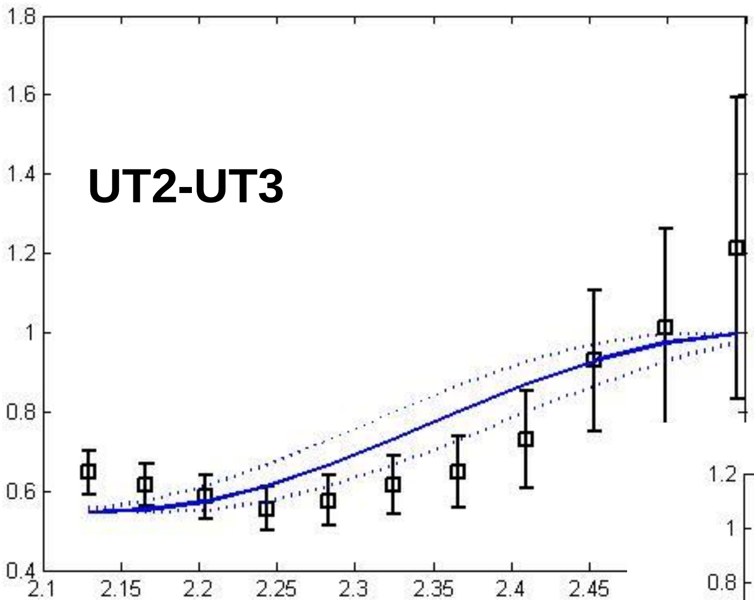
$B = a(-\sin\omega\cos\Omega - \cos\omega\sin\Omega\cos i)$

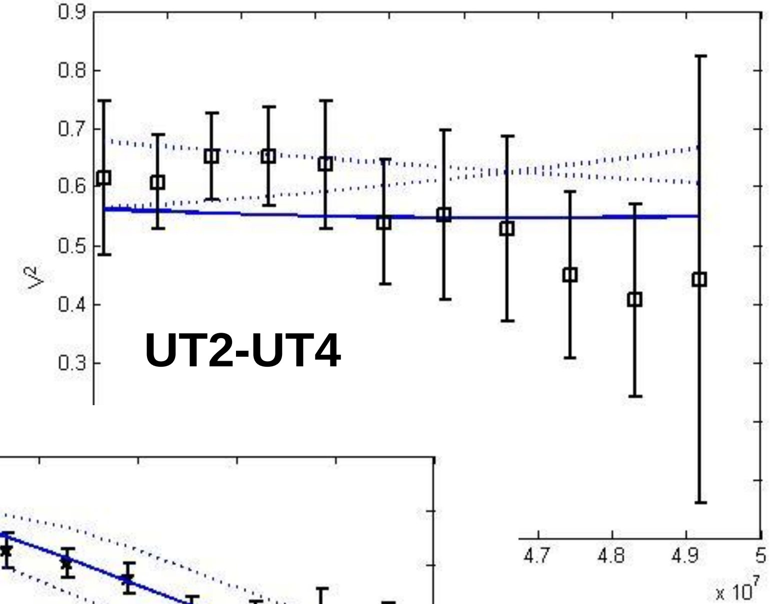
$C = a(\cos\omega\sin\Omega + \sin\omega\sin\Omega\cos i)$

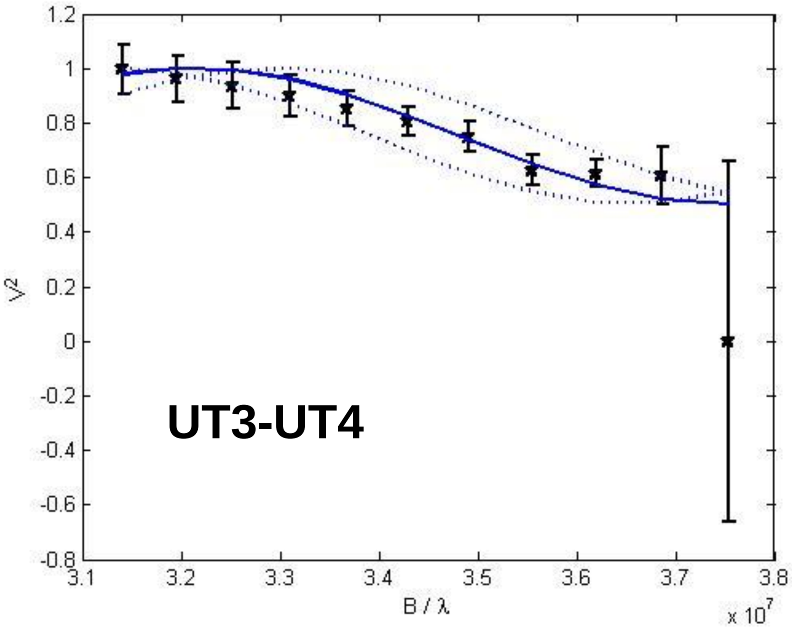
$D = a(-\sin\omega\cos\Omega + \cos\omega\sin\Omega\cos i)$

B_x=projected x baseline
B_y=projected y baseline
f=flux ratio at λ
E=eccentric anomaly
M=mean anomaly
t_{obs}=jd of observation
τ=time of periastron
P=period
e=eccentricity
ω=longitude of periastron
Ω=longitude of ascendig node
i=inclination
a=semimajor axes

Comparison with model



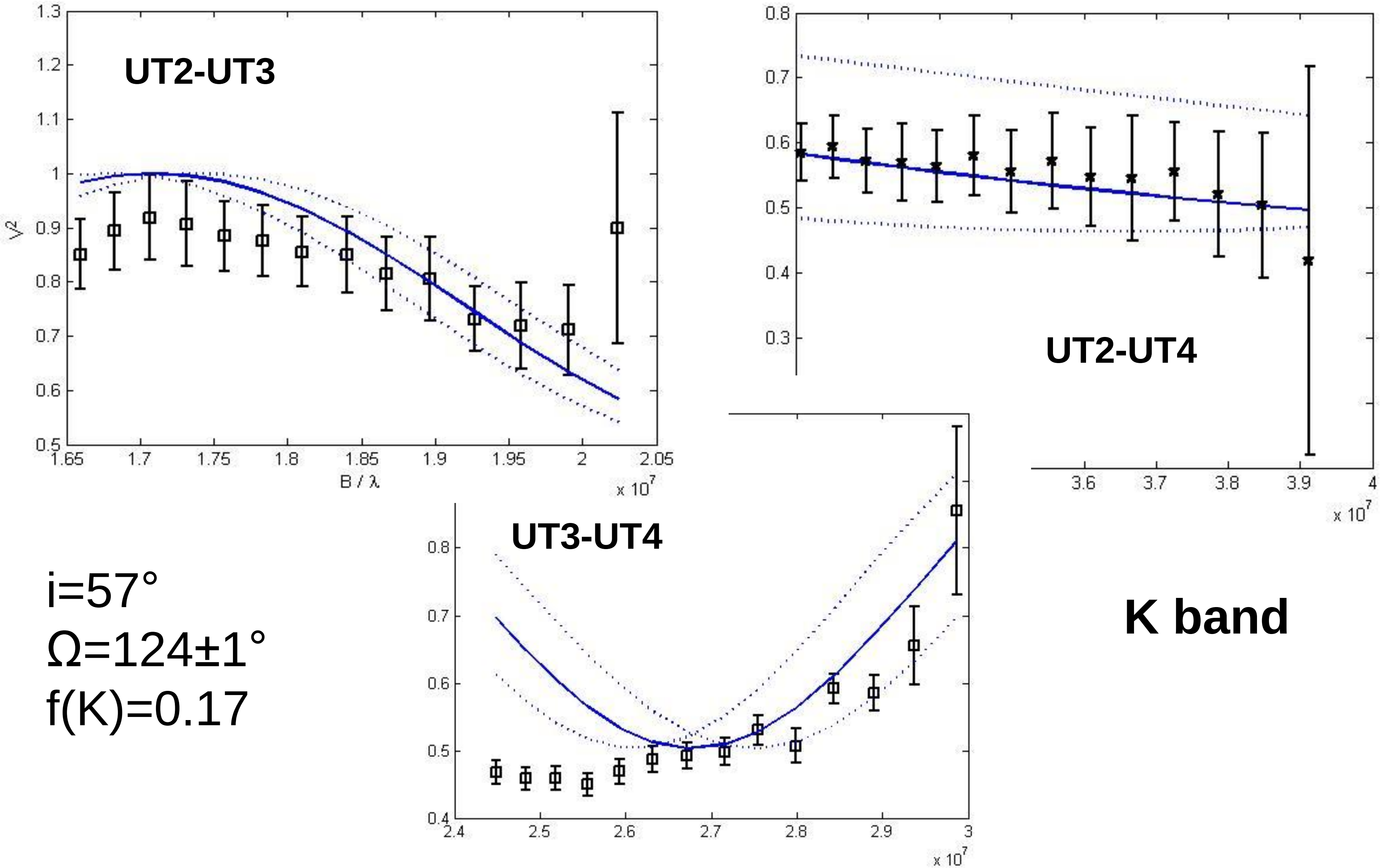




i=57°
Ω=124±1°
f(H)=0.15

H band

Comparison with model



i=57°
Ω=124±1°
f(K)=0.17

K band

Results

$i=57\pm3°$

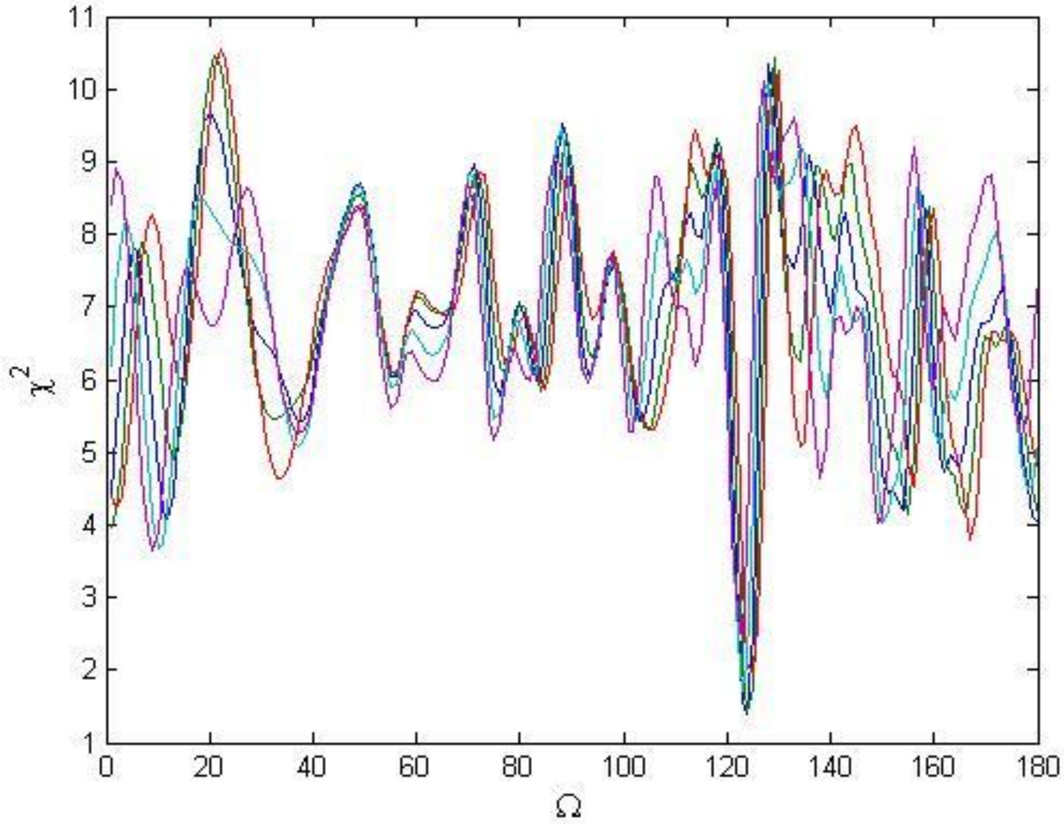
$\Omega=124\pm4°$

$f(K)=0.17\pm0.02$

$f(H)=0.15\pm0.02$

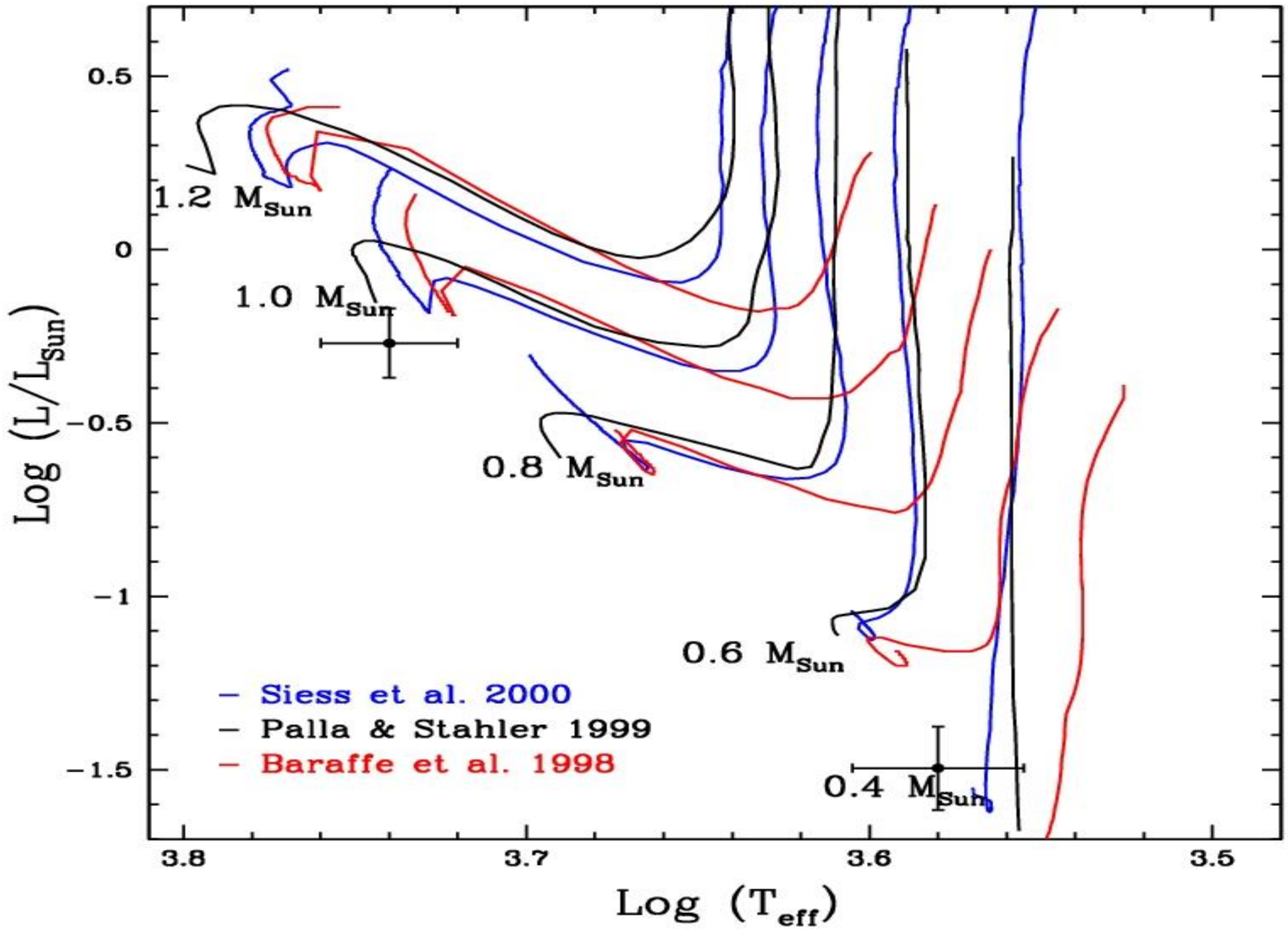
$M_1=1.05\pm0.13\ M_☼$

$M_2=0.60\pm0.07\ M_☼$



$d=a/P^{2/3}(M1+M2)^{1/3}=18.65\pm2.04$ pc

HD113449 on the HR diagram



PMS binaries with P > 100 d

Schaefer et al. 2008

$M_1=0.96^{+0.27}_{-0.08}\ M_{\odot}$

$M_2=0.33^{+0.09}_{-0.02}\ M_{\odot}$

Boden et al.2005

$M_1=0.699\pm0.064\ M_{\odot}$

$M_2=0.582\pm0.051\ M_{\odot}$

Steffen et al. 2001

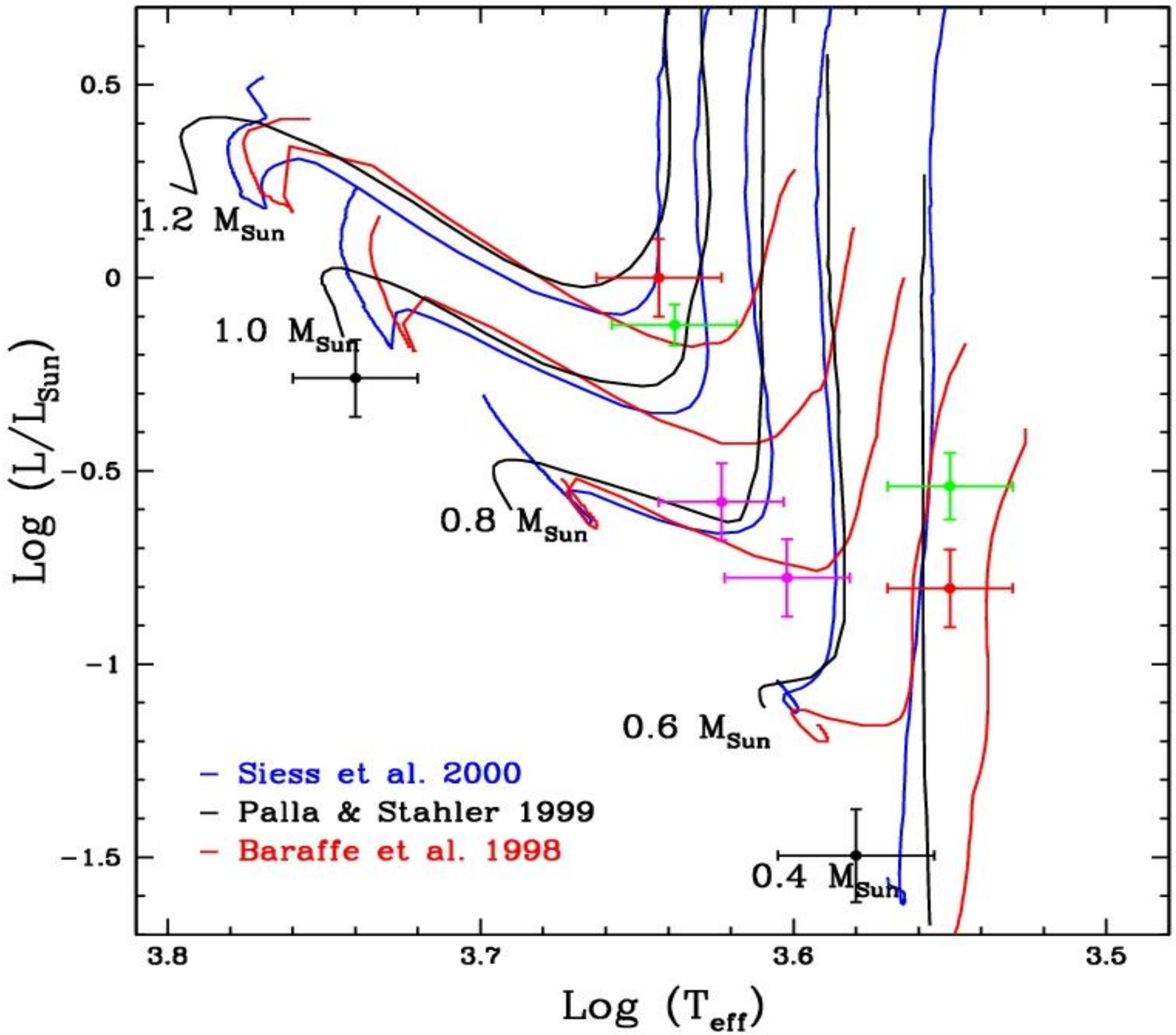
$M_1=1.45\pm0.19\ M_{\odot}$

$M_2=0.81\pm0.09\ M_{\odot}$

Our

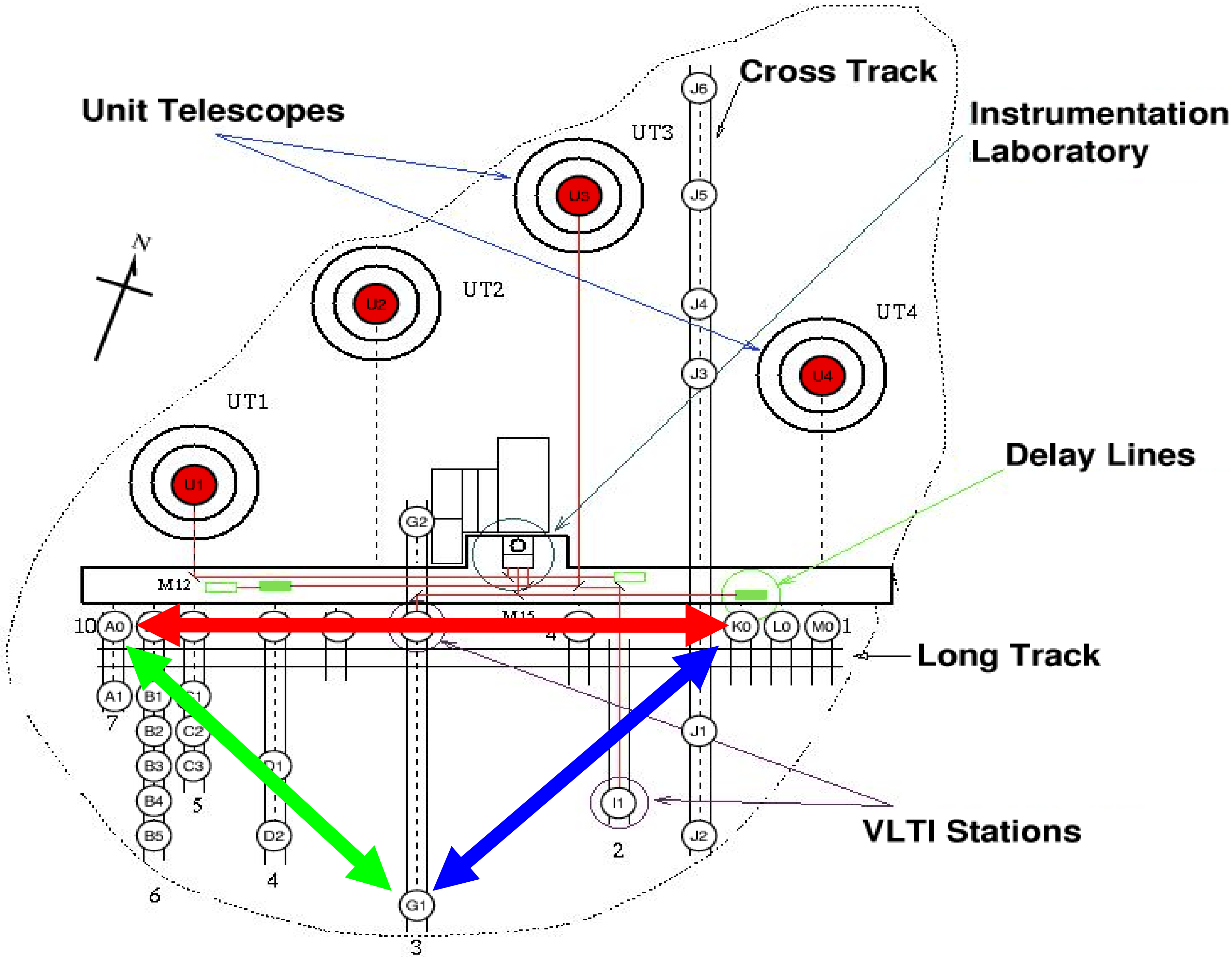
$M_1=1.05\pm0.13\ M_{\odot}$

$M_2=0.60\pm0.07\ M_{\odot}$

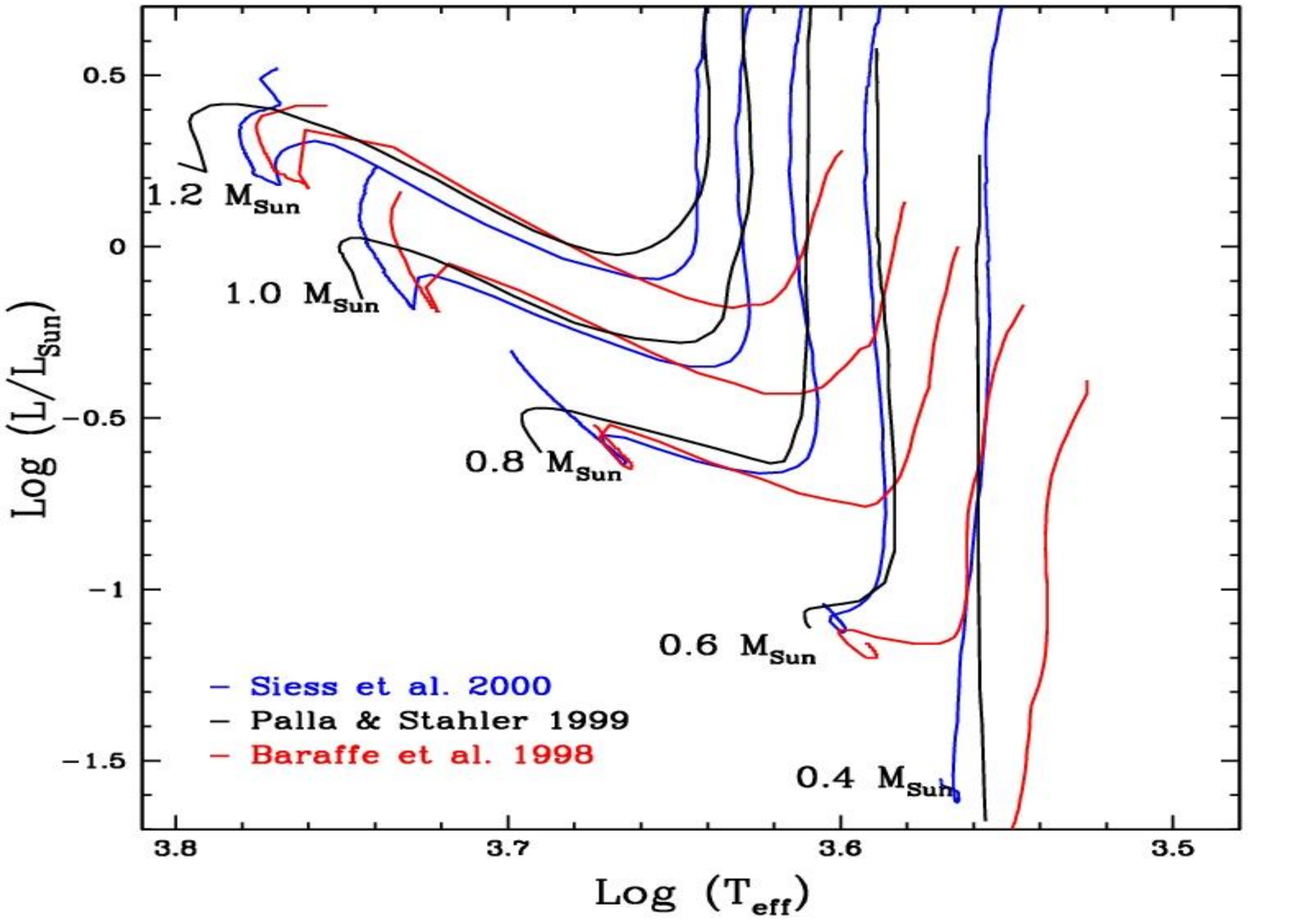


Conclusions

- Combining spectroscopy and NIR-interferometry we have determined the dynamical masses of two young stars in a binary system M_1=1.05±0.13 $M_☼$ M_2=0.60±0.07 $M_☼$
- PMS tracks from three different authors are in disagreement with our estimation
- Our result is consistent with other works on long period PMS binaries
- Models for young stars should be revisited



Unit Telescopes
Cross Track
Instrumentation Laboratory
Delay Lines
Long Track
VLTI Stations
UT1
UT2
UT3
UT4
U1
U2
U3
U4
N
J6
J5
J4
J3
J1
J2
G2
G1
M12
M15
A0
K0
L0
M0
A1
B1
B2
B3
B4
B5
C2
C3
D1
D2
I1
10
1
2
3
4
5
6
7



0.5
0
−0.5
−1
−1.5
3.8
3.7
3.6
3.5
Log (L/L$_{Sun}$)
Log (T$_{eff}$)
1.2 M$_{Sun}$
1.0 M$_{Sun}$
0.8 M$_{Sun}$
0.6 M$_{Sun}$
0.4 M$_{Sun}$
– Siess et al. 2000
– Palla & Stahler 1999
– Baraffe et al. 1998

First test with mass ratios

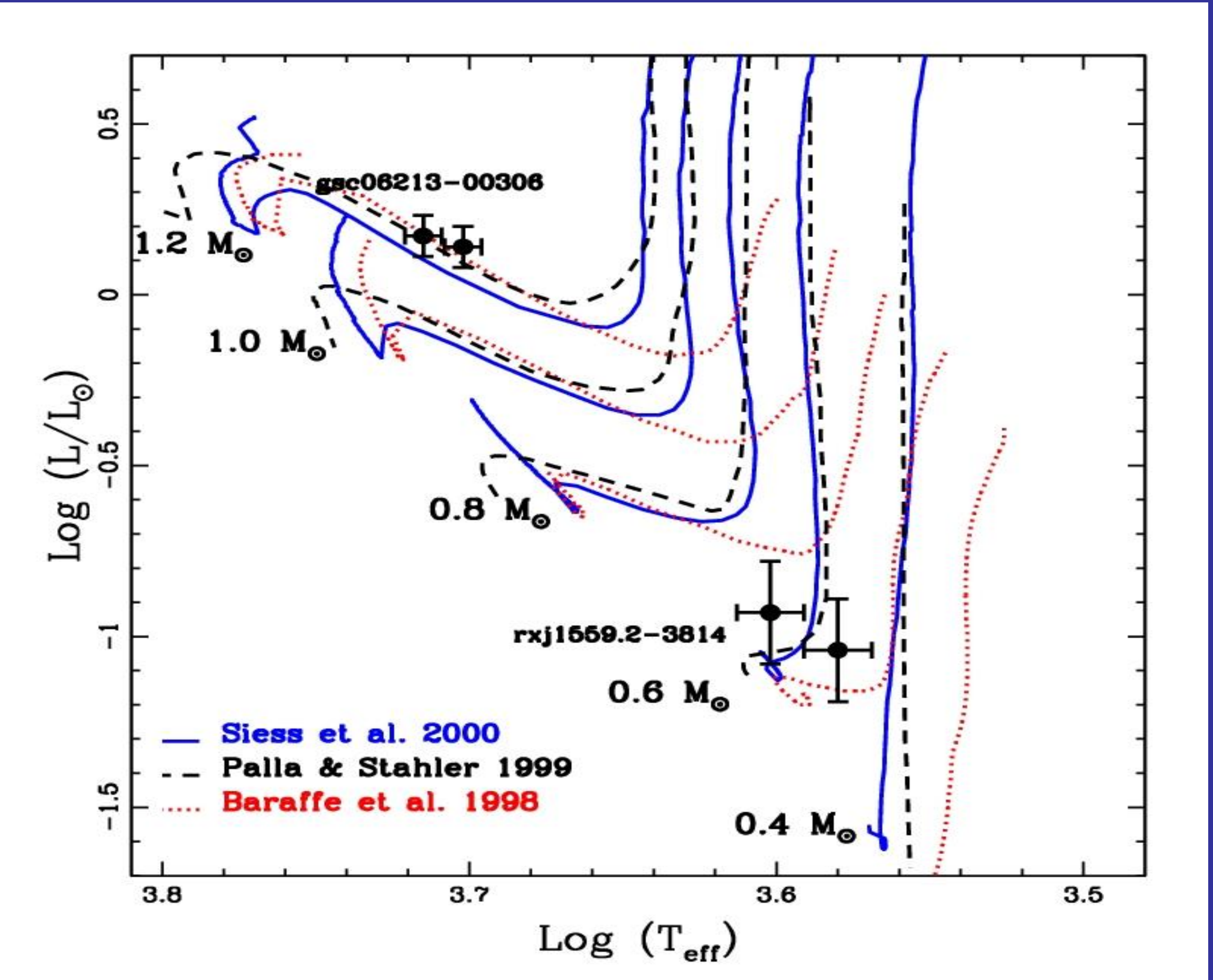
L and T_{eff} determined using spectral synthesis and line ratios

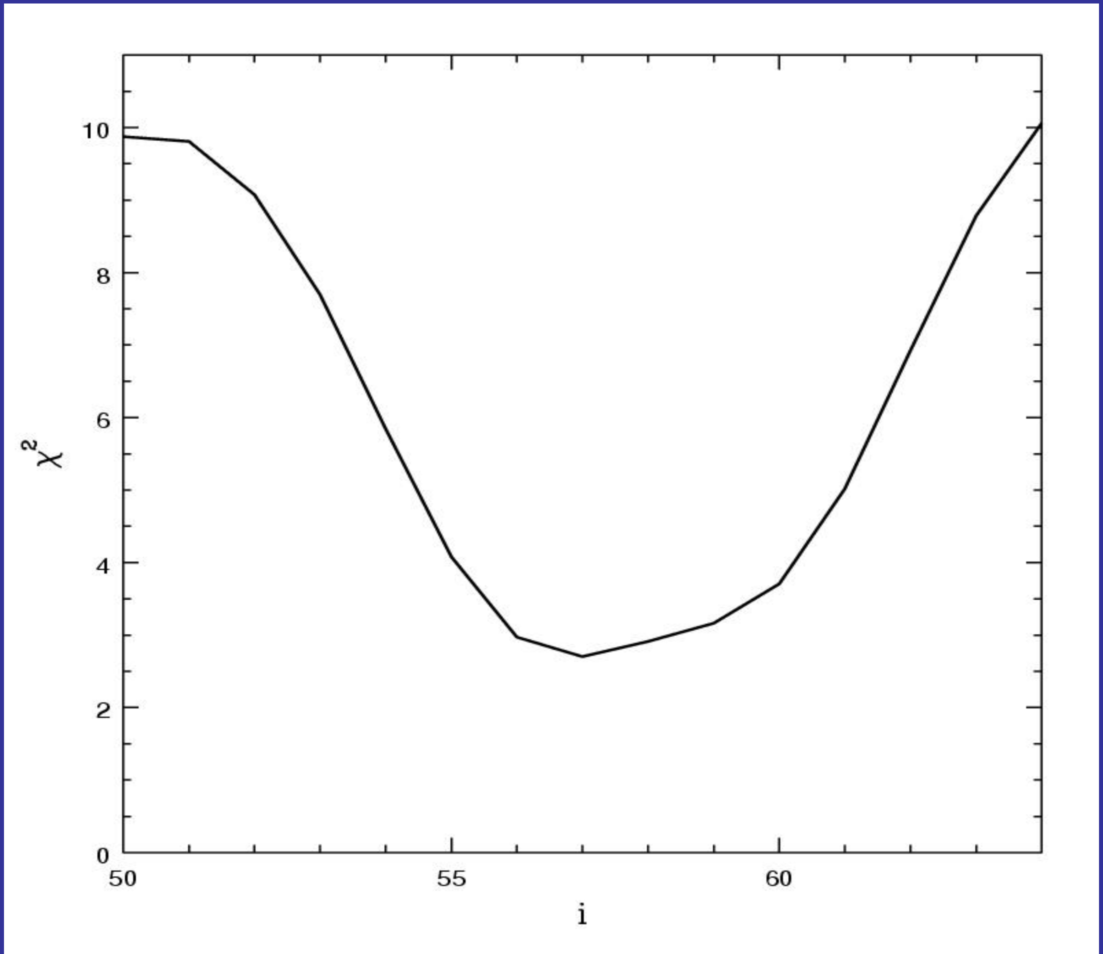
RXJ1559.2-3814
q=0.95±0.03

q_{sie}=0.77
q_{pal}=0.83
q_{bar} =0.93

GSC06213-00306
q=0.97±0.01

q_{sie} ≈ 1
q_{pal} ≈ 1
q_{bar} ≈1





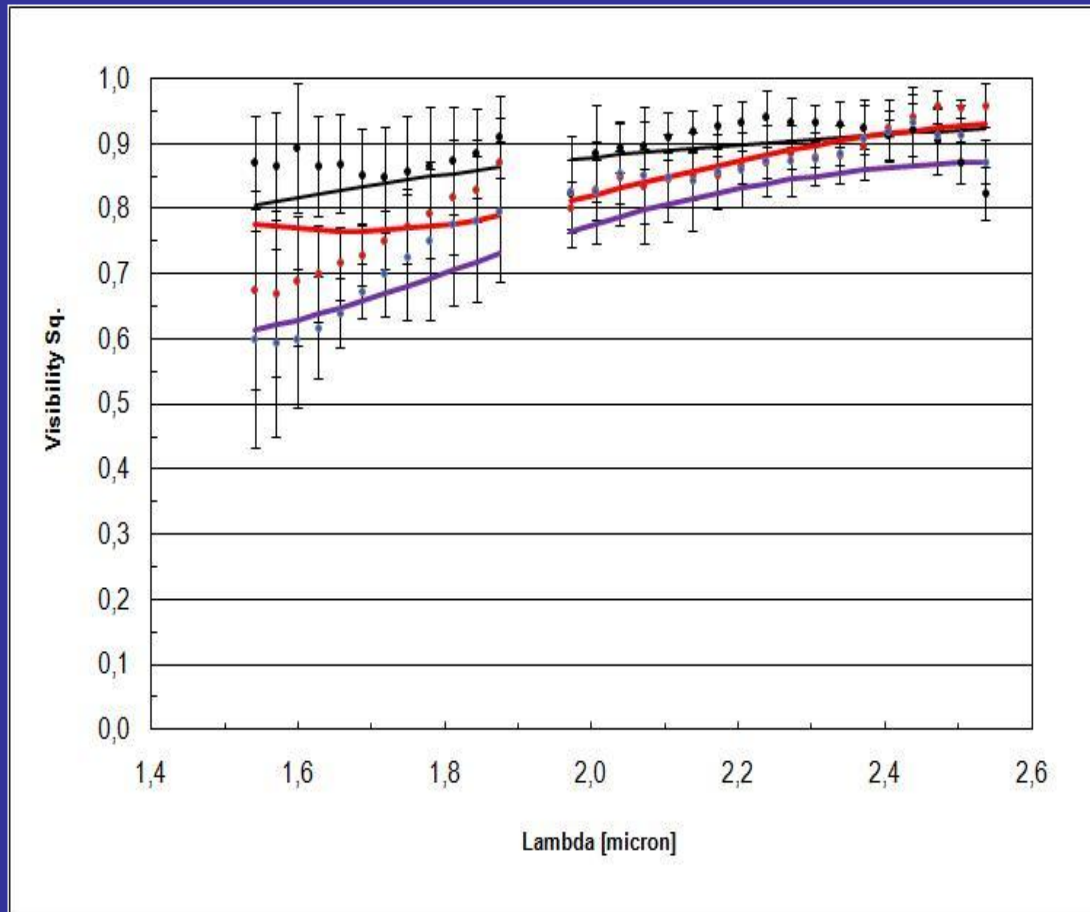
10
8
6
4
2
0
χ^2
50
55
60
i

AstronomicalDatabase. The parallaxes are from van Leeuwen (2007).

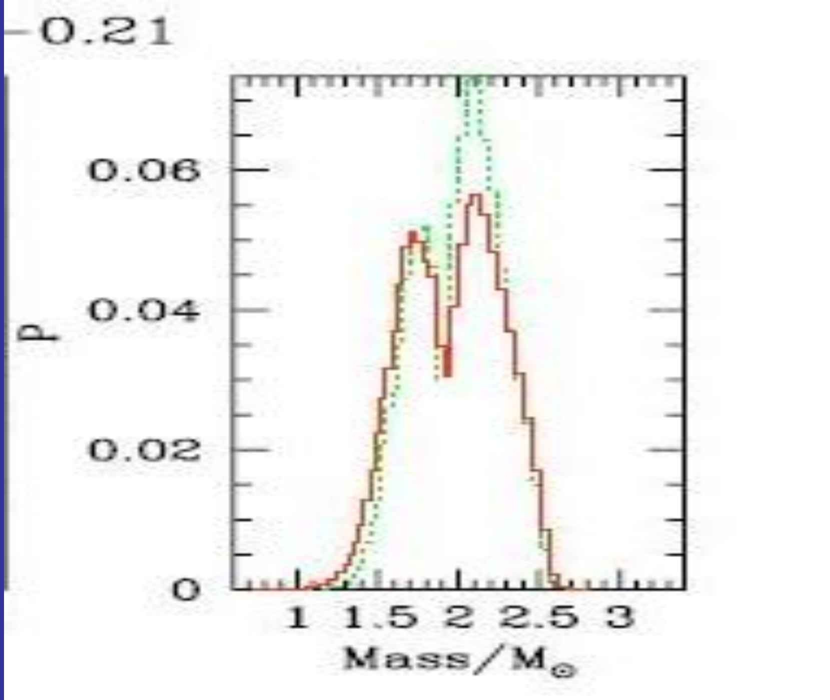
id	V (mag)	K (mag)	Spec. Type	π (mas)	θ_{UD} (mas)	θ_{LD} (mas)	R_{linear} ($R_\odot$)	L ($L_\odot$)	T_{eff}
HD32518	6.41	3.91 ± 0.04	K1 III	8.29 ± 0.58	0.828 ± 0.022	0.851 ± 0.022	11.04 ± 0.77	46.0 ± 2.7	4524 ± 98
HD60294	5.92	3.55 ± 0.22	K2 III	12.24 ± 0.39	1.014 ± 0.010	1.044 ± 0.010	9.17 ± 0.29	32.5 ± 1.6	4552 ± 63
HD73108	4.60	1.92 ± 0.07	K1 III	12.74 ± 0.26	2.161 ± 0.019	2.225 ± 0.020	18.79 ± 0.38	111.1 ± 7.9	4324 ± 80
HD102328	5.29	2.55 ± 0.06	K3 III	15.13 ± 0.30	1.546 ± 0.006	1.606 ± 0.006	11.42 ± 0.23	42.7 ± 3.2	4367 ± 82
HD103605	5.84	3.10 ± 0.30	K1 III	10.54 ± 0.37	1.066 ± 0.009	1.098 ± 0.010	11.20 ± 0.41	52.8 ± 3.9	4647 ± 91
HD106574	5.71	2.94 ± 0.08	K2 III	7.00 ± 0.28	1.458 ± 0.027	1.498 ± 0.028	23.02 ± 0.92	134.7 ± 10	4099 ± 88
HD113049	6.00	3.66 ± 0.31	K0 III	6.02 ± 0.37	0.945 ± 0.021	0.971 ± 0.022	17.35 ± 1.07	119.5 ± 5.9	4581 ± 85
HD118904	5.51	2.69 ± 0.07	K2 III	7.93 ± 0.24	1.842 ± 0.031	1.871 ± 0.031	25.38 ± 0.88	135.3 ± 11.5	3908 ± 91
HD136726	5.01	1.92 ± 0.05	K4 III	8.19 ± 0.19	2.264 ± 0.020	2.293 ± 0.020	30.12 ± 0.70	229.2 ± 23.3	4093 ± 106
HD137443	5.79	2.74 ± 0.06	K4 III	8.86 ± 0.22	1.638 ± 0.030	1.690 ± 0.031	20.51 ± 0.62	96.0 ± 9.5	3989 ± 106
HD138265	5.88	2.38 ± 0.04	K5 III	5.11 ± 0.31	1.998 ± 0.037	2.062 ± 0.038	43.40 ± 2.75	338.5 ± 47.5	3758 ± 139
HD139357	5.97	3.41 ± 0.32	K4 III	8.47 ± 0.30	1.040 ± 0.012	1.073 ± 0.013	13.63 ± 0.51	72.8 ± 4.0	4567 ± 72
HD150010	6.28	3.18 ± 0.38	K2 III	6.95 ± 0.43	0.995 ± 0.028	1.024 ± 0.029	15.84 ± 1.08	98.7 ± 10.0	4570 ± 136
HD152812	6.00	2.83 ± 0.09	K2 III	4.97 ± 0.45	1.393 ± 0.003	1.440 ± 0.004	31.16 ± 2.82	260.3 ± 25.6	4153 ± 113
HD157681	5.67	2.19 ± 0.05	K5 III	5.23 ± 0.27	1.600 ± 0.009	1.664 ± 0.010	34.22 ± 1.78	384.9 ± 54.0	4371 ± 156
HD160290	5.36	2.67 ± 0.07	K1 III	9.23 ± 0.12	1.467 ± 0.010	1.515 ± 0.010	17.65 ± 0.42	113.9 ± 8.0	4487 ± 81
HD167042	5.98	3.44 ± 0.24	K1 III	19.91 ± 0.26	0.898 ± 0.017	0.922 ± 0.018	4.98 ± 0.07	11.7 ± 0.6	4782 ± 81
HD170693	4.83	1.95 ± 0.05	K1.5 III	10.36 ± 0.20	1.981 ± 0.041	2.041 ± 0.043	21.19 ± 0.60	144.7 ± 11.4	4349 ± 98
HD175823	6.22	3.57 ± 0.32	K5 III	5.63 ± 0.28	0.958 ± 0.022	0.988 ± 0.023	18.88 ± 1.04	132.2 ± 9.3	4505 ± 99
HD176408	5.66	3.00 ± 0.27	K1 III	11.81 ± 0.27	1.092 ± 0.022	1.125 ± 0.023	10.24 ± 0.23	48.3 ± 3.4	4735 ± 97
HD186815	6.28	4.32 ± 0.25	K2 III	12.86 ± 0.39	0.713 ± 0.020	0.731 ± 0.020	6.11 ± 0.25	18.0 ± 0.5	4809 ± 76
HD192781	5.79	2.33 ± 0.07	K5 III	5.62 ± 0.23	1.787 ± 0.002	1.859 ± 0.003	35.57 ± 1.46	394.6 ± 33.5	4313 ± 94
HD195820	6.18	3.90 ± 0.22	K0 III	8.68 ± 0.29	0.840 ± 0.040	0.863 ± 0.041	10.69 ± 0.62	50.3 ± 2.3	4700 ± 125
HD200205	5.51	2.25 ± 0.06	K4 III	5.30 ± 0.24	1.963 ± 0.043	2.032 ± 0.045	41.23 ± 2.08	519.3 ± 36.4	4291 ± 92
HD214868	4.48	1.41 ± 0.07	K2 III	9.08 ± 0.26	2.721 ± 0.020	2.731 ± 0.024	29.98 ± 0.84	283.6 ± 27.9	4327 ± 109

id	V (mag)	K (mag)	Spec. Type	π	θ_H (mas)	θ_K (mas)	R_{linear}($R_\odot$)	L ($L_\odot$)	T_{eff}
HD11977	4.70	2.590 ± 0.240	G8.5 III	14.91 ± 0.16	1.579 ± 0.013	1.573 ± 0.015	11.37 ± 0.12	64.5 ± 2.3	4855 ± 84
HD12438	5.35	3.218 ± 0.298	G5 III	11.08 ± 0.29	1.100 ± 0.050	1.150 ± 0.050	10.68 ± 0.28	58.5 ± 6.1	5005 ± 150
HD23319	4.60	2.639 ± 0.274	K2.5 III	17.70 ± 0.22	1.962 ± 0.009	1.929 ± 0.019	11.82 ± 0.15	51.4 ± 5.5	4498 ± 126
HD27256	3.34	1.439 ± 0.312	G8 II-III	20.18 ± 0.10	2.563 ± 0.010	2.559 ± 0.002	13.64 ± 0.07	103.0 ± 5.9	4981 ± 78
HD36848	5.46	2.804 ± 0.268	K2 III	18.93 ± 0.23	1.369 ± 0.017	1.369 ± 0.025	7.77 ± 0.09	17.8 ± 1.0	4280 ± 86

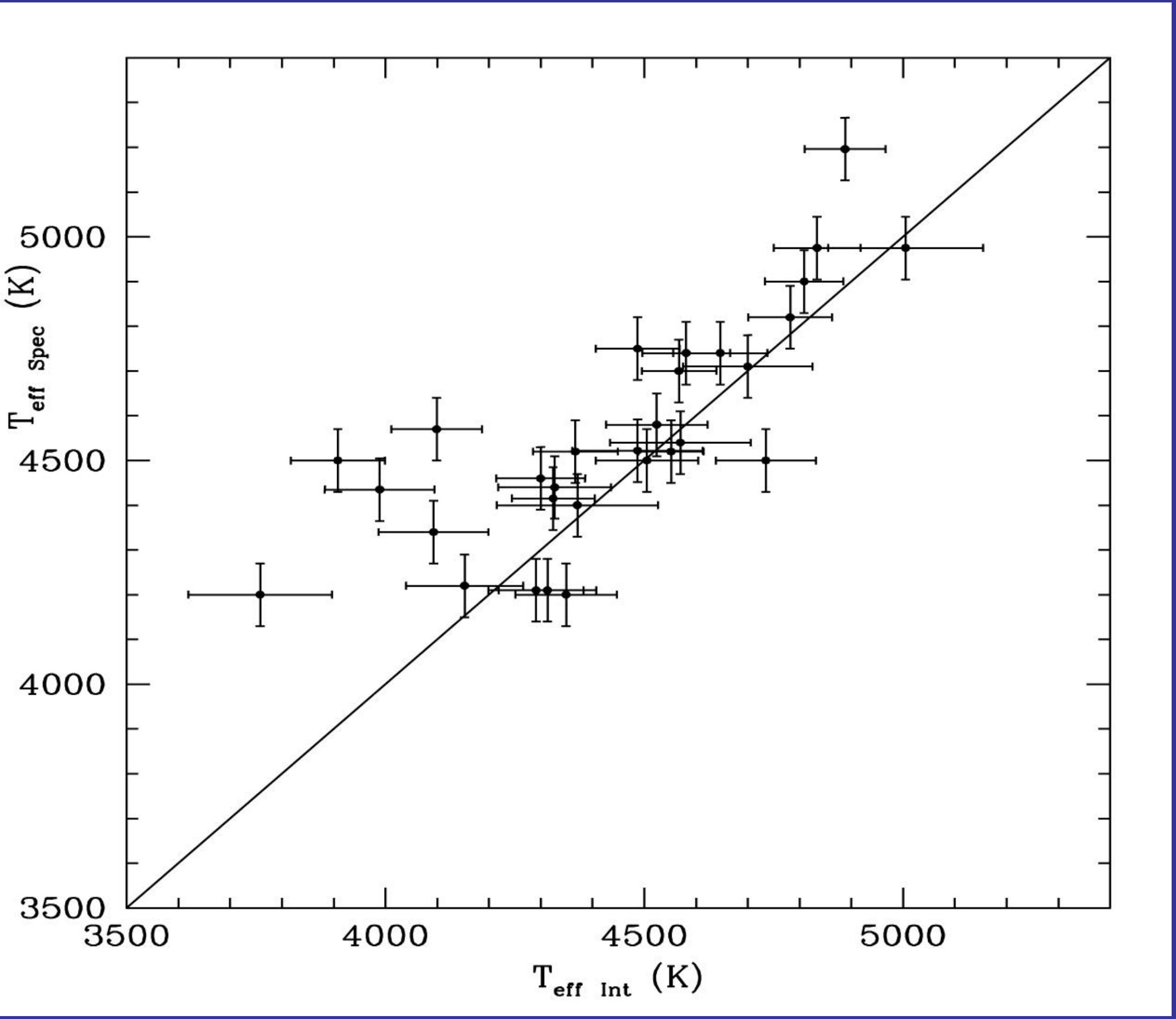
Table 9.1: Diameters measured with AMBER for the 5 giants. Note that for HD12438 is given the angular diameter obtained by fitting the model of a resolved binary as explained in the text. The V magnitude and the spectral types are from SIMBAD.The K magnitude are from 2MASS. The parallaxes are from van Leeuwen (2007).



1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
Visibility Sq.
1,4
1,6
1,8
2,0
2,2
2,4
2,6
Lambda [micron]



- da Silva et al 2006



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4500
4000
3500
3500
4000
4500
5000
$T_{eff\ Spec}$ (K)
$T_{eff\ Int}$ (K)