Fundamental Properties of O and B Stars

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March 19th, 2013

with:
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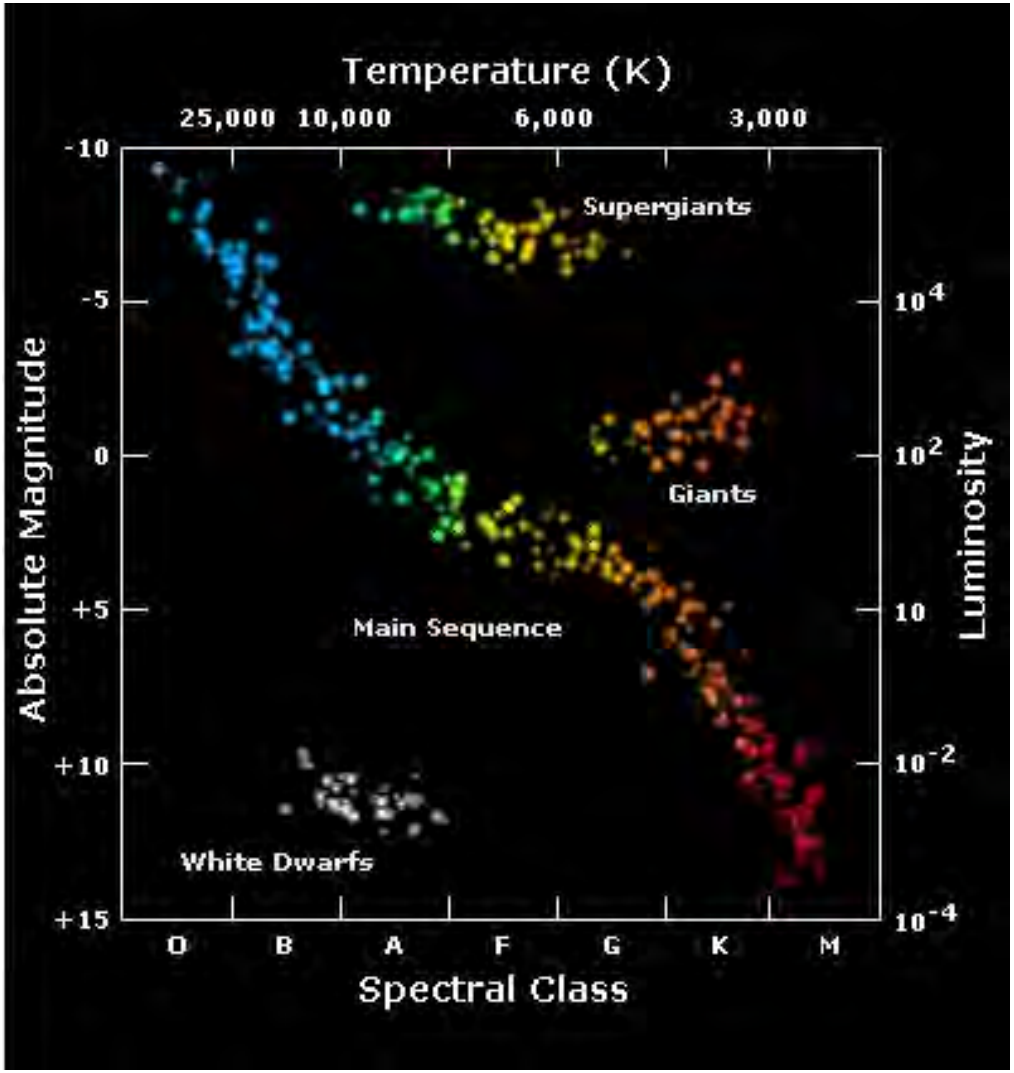
What is our goal?

- **Radius, temperature, mass, age**

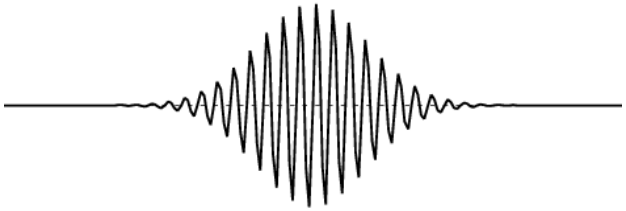
- **Model dependent!**
  - **Color and spectra**
  - **Large errors in luminosity**



(1)

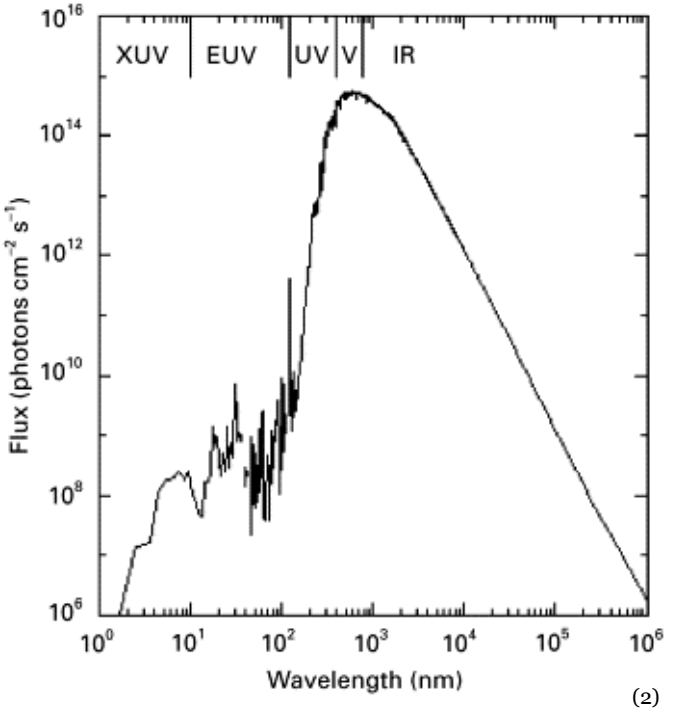
Observationally determined properties

- **Angular size + distance → Radius**
  - **» Interferometry**



- **Integrated flux + angular size → Effective Temperature**
  - **» Spectrophotometry**

$$F_{obs} = \frac{1}{4}\alpha^2 F_{em} \qquad F_{em} = \sigma T_{eff}^4$$



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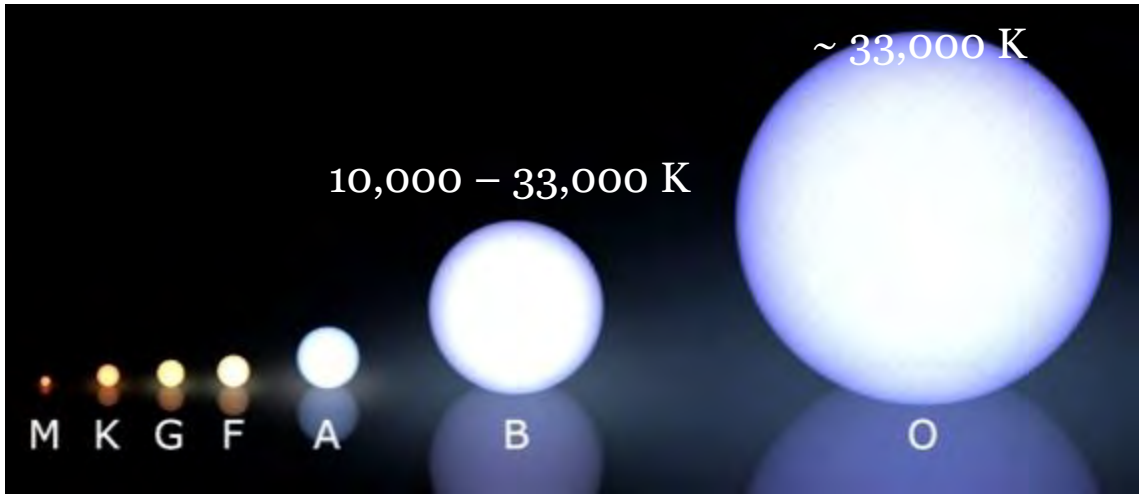
Our Targets

- **10 O stars**
- **189 B stars**



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Priority:

*** O stars**
*** Known parallax with errors less than 10%**
*** Cluster member**
*** Single star targets**

- **10 O stars**
- **72 B stars**

Hanbury Brown et al. (1974)

4 O stars
16 B stars

<u>Overlap with our sample:</u>

2 O stars
8 B stars

TABLE III

The uniform disc angular diameters, true angular diameters and normalized zero-baseline correlations for 32 stars

1	2	3	4	5	6
B.S.	Name	MK	$C_N \pm \sigma$ (normalized)	$\bar{\theta}_{UD} \pm \sigma$ (10^{-3} seconds of arc)	$\theta_{LD} \pm \sigma$ (10^{-3} seconds of arc)
472	α Eri	‡B3 Vp	0·98 ± 0·05	1·85 ± 0·07	1·92 ± 0·07
1713	β Ori	†B8 Ia	0·98 ± 0·08	2·43 ± 0·05	2·55 ± 0·05
1790	γ Ori	†B2 III	1·03 ± 0·07	0·70 ± 0·04	0·72 ± 0·04
1903	ε Ori	†Bo Ia	0·86 ± 0·07	0·67 ± 0·04	0·69 ± 0·04
1948	ζ Ori	**O9·5 Ib	0·60 ± 0·06	0·47 ± 0·04	0·48 ± 0·04
2004	κ Ori	†Bo·5 Ia	1·18 ± 0·09	0·44 ± 0·03	0·45 ± 0·03
2294	β CMa	*B1 II–III	1·07 ± 0·08	0·50 ± 0·03	0·52 ± 0·03
2326	α Car	Fo Ib–II	0·75 ± 0·22	6·1 ± 0·7	6·6 ± 0·8
2421	γ Gem	**Ao IV	1·17 ± 0·09	1·32 ± 0·09	1·39 ± 0·09
2491	α CMa	A1 V	0·91 ± 0·06	5·60 ± 0·15	5·89 ± 0·16
2618	ε CMa	**B2 II	0·89 ± 0·06	0·77 ± 0·05	0·80 ± 0·05
2693	δ CMa	**F8 Ia	0·93 ± 0·18	3·29 ± 0·46	3·60 ± 0·50
2827	η CMa	†B5 Ia	0·99 ± 0·09	0·72 ± 0·06	0·75 ± 0·06
2943	α CMi	F5 IV–V	0·98 ± 0·10	5·10 ± 0·16	5·50 ± 0·17
3165	ζ Pup	†O5 f	1·04 ± 0·08	0·41 ± 0·03	0·42 ± 0·03
3207	γ^2 Vel	§WC8 + O9 I	—	0·43 ± 0·05	0·44 ± 0·05
3685	β Car	A1 IV	1·01 ± 0·06	1·51 ± 0·07	1·59 ± 0·07
3982	α Leo	**B7 V	1·12 ± 0·07	1·32 ± 0·06	1·37 ± 0·06
4534	β Leo	**A3 V	1·17 ± 0·10	1·25 ± 0·09	1·33 ± 0·10
4662	γ Crv	B8 III	0·97 ± 0·10	0·72 ± 0·06	0·75 ± 0·06
4853	β Cru	‡Bo·5 III	0·88 ± 0·03	0·702 ± 0·022	0·722 ± 0·023
5056	α Vir	*B1 IV	—	0·85 ± 0·04	0·87 ± 0·04
5132	ε Cen	‡B1 III	1·02 ± 0·07	0·47 ± 0·03	0·48 ± 0·03
5953	δ Sco	†Bo·5 IV	0·75 ± 0·07	0·45 ± 0·04	0·46 ± 0·04
6175	ζ Oph	**O9·5 V	1·01 ± 0·12	0·50 ± 0·05	0·51 ± 0·05
6556	α Oph	**A5 III	0·94 ± 0·09	1·53 ± 0·12	1·63 ± 0·13
6879	ε Sgr	Ao V	1·02 ± 0·06	1·37 ± 0·06	1·44 ± 0·06
7001	α Lyr	†Ao V	0·99 ± 0·04	3·08 ± 0·07	3·24 ± 0·07
7557	α Aql	A7 IV, V	0·94 ± 0·06	2·78 ± 0·13	2·98 ± 0·14
7790	α Pav	‡B2·5 V	1·01 ± 0·07	0·77 ± 0·05	0·80 ± 0·05
8425	α Gru	‡B7 IV	1·11 ± 0·08	0·98 ± 0·07	1·02 ± 0·07
8728	α PsA	†A3 V	1·02 ± 0·08	1·98 ± 0·13	2·10 ± 0·14

Observations

- **Target sizes range from 0.2 to 1.4 mas**

- **CLASSIC & CLIMB: 0.5 to 1.4 mas stars, H-band**

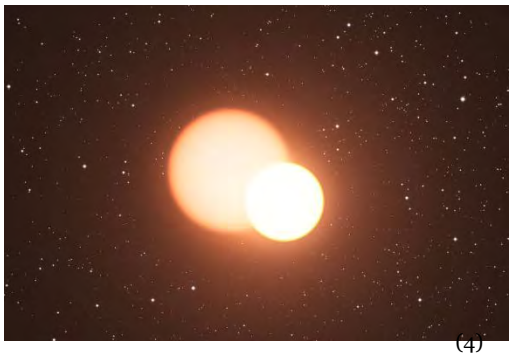
  Observe on two different baselines (with CLASSIC)

- **PAVO: 0.2 to 0.5 mas stars, 2T**

  Observe on two different baselines

→ Observe some stars with both combiners

Challenges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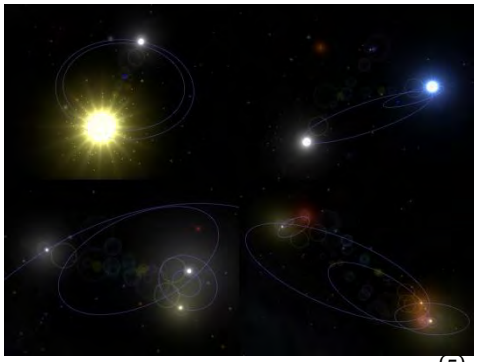
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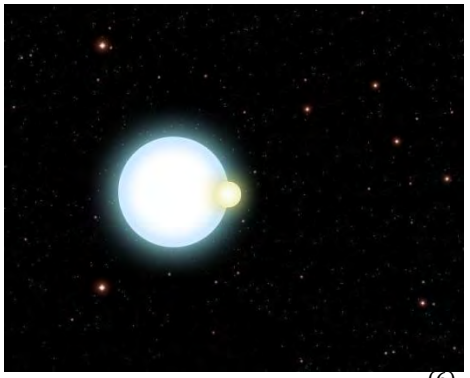
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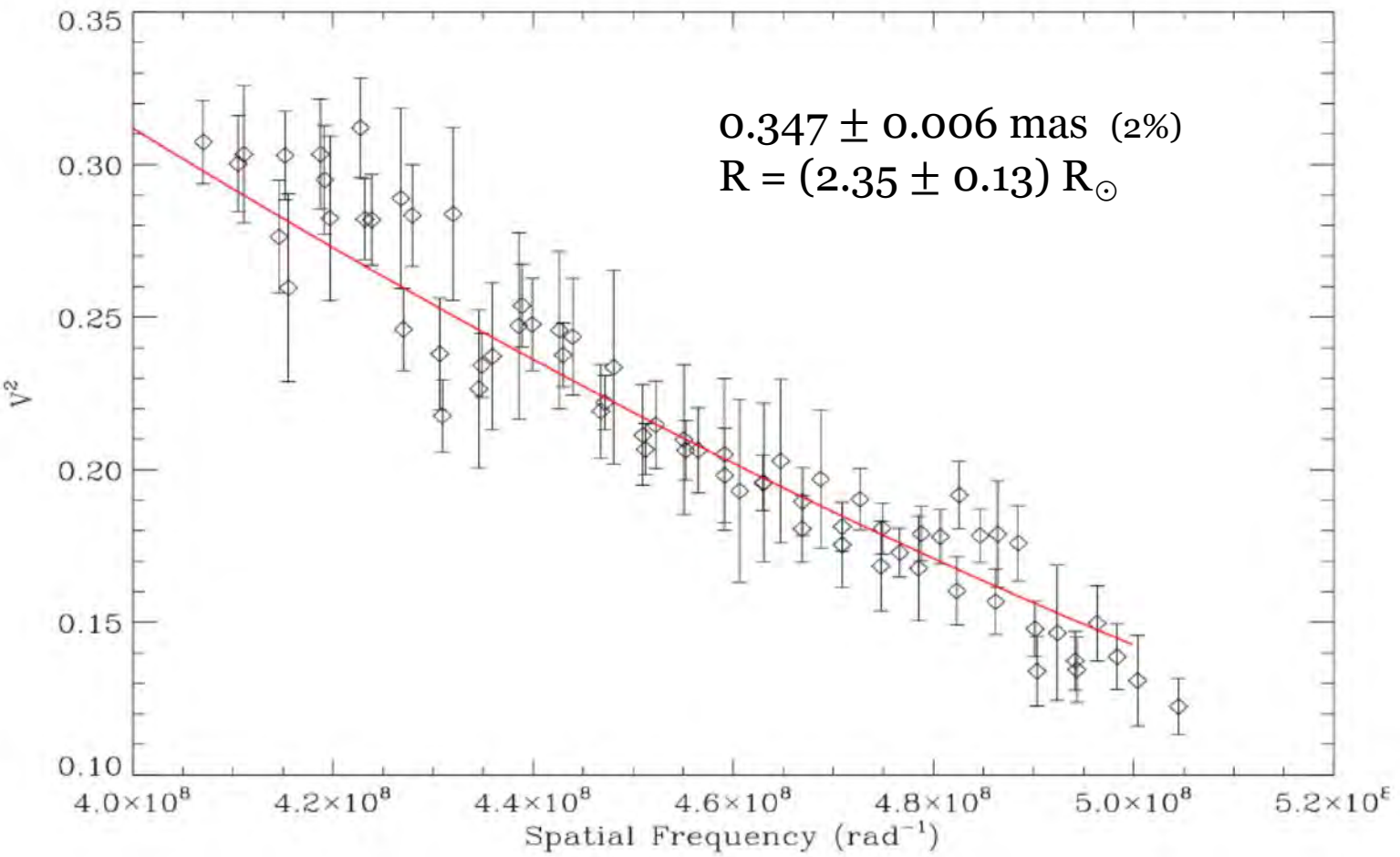
- **Many massive stars are in binary or multiple star systems!**
- **Not many stars nearby → smaller angular sizes**
- **Working close to resolution limits of CHARA**
- **Good calibrators harder to find**

Results (so far)

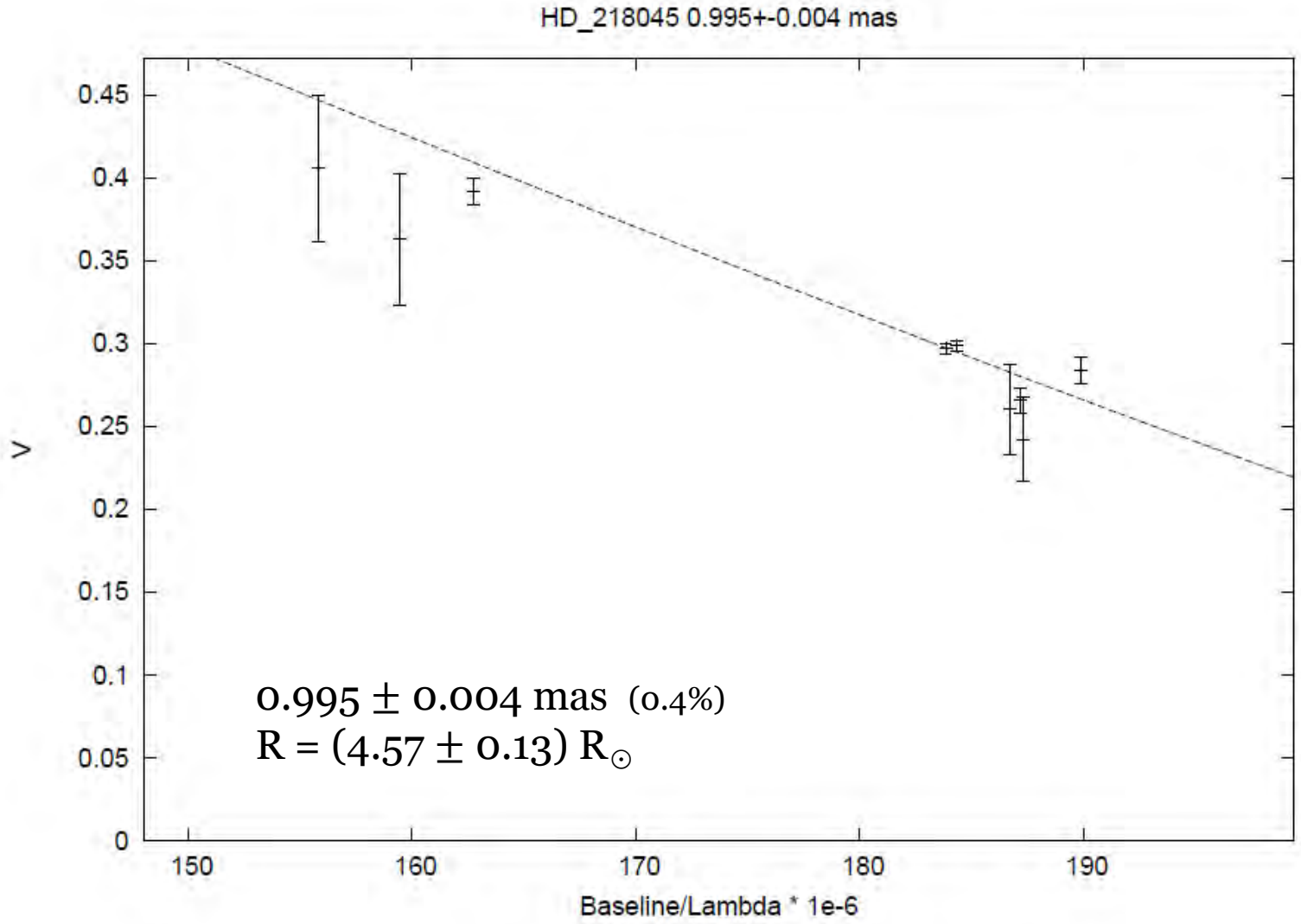
- 6 nights of data on 13 stars from two observing runs
- 2 to 5 brackets per star
- Data from CLIMB, CLASSIC, and PAVO

HD 11502 (3 brackets)



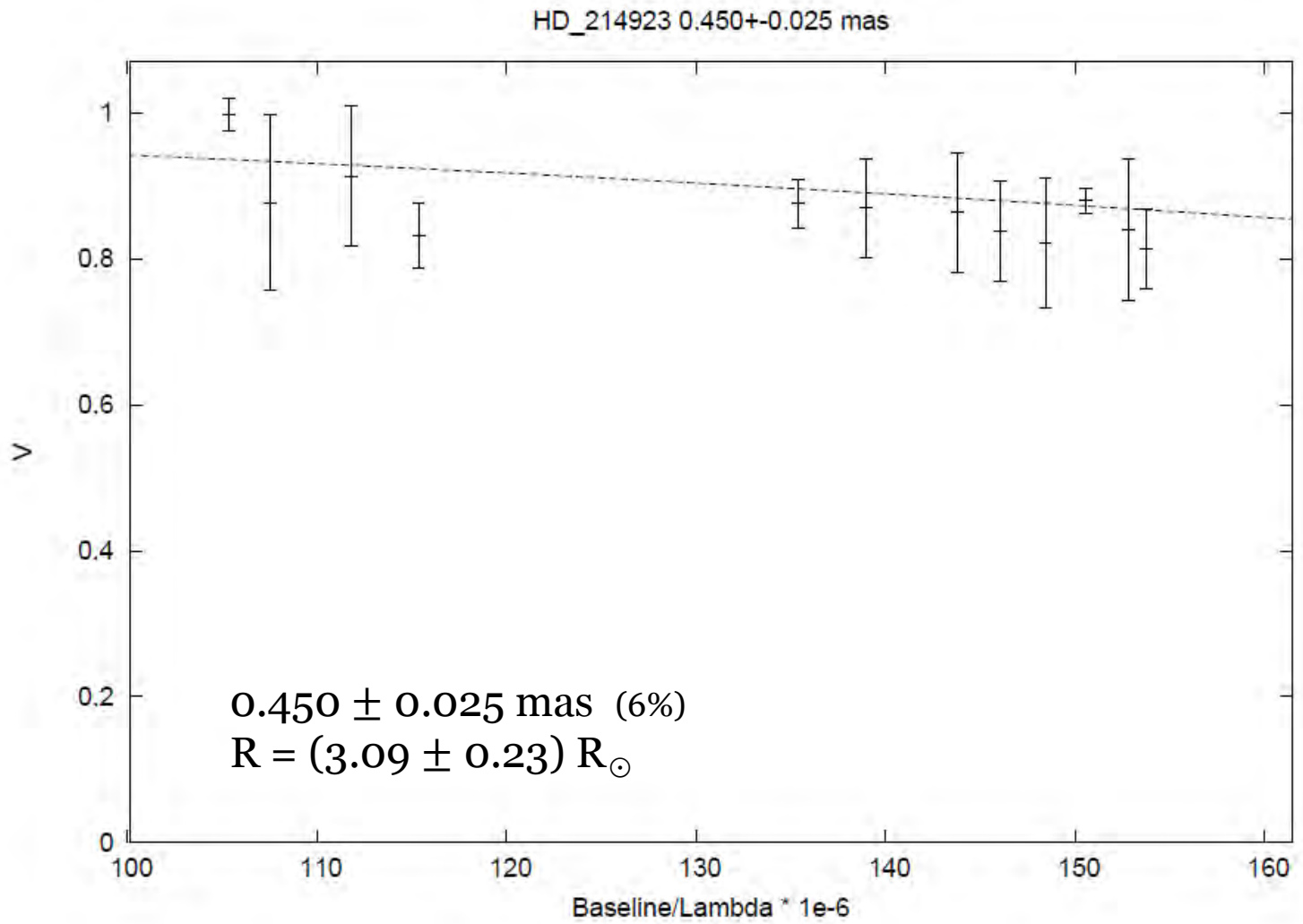
B9 V **V=4.7** **~63 pc**

HD 218045/Markab (3 brackets)



B9 III **V=2.49** **~43 pc**

HD 214923 (4 brackets)

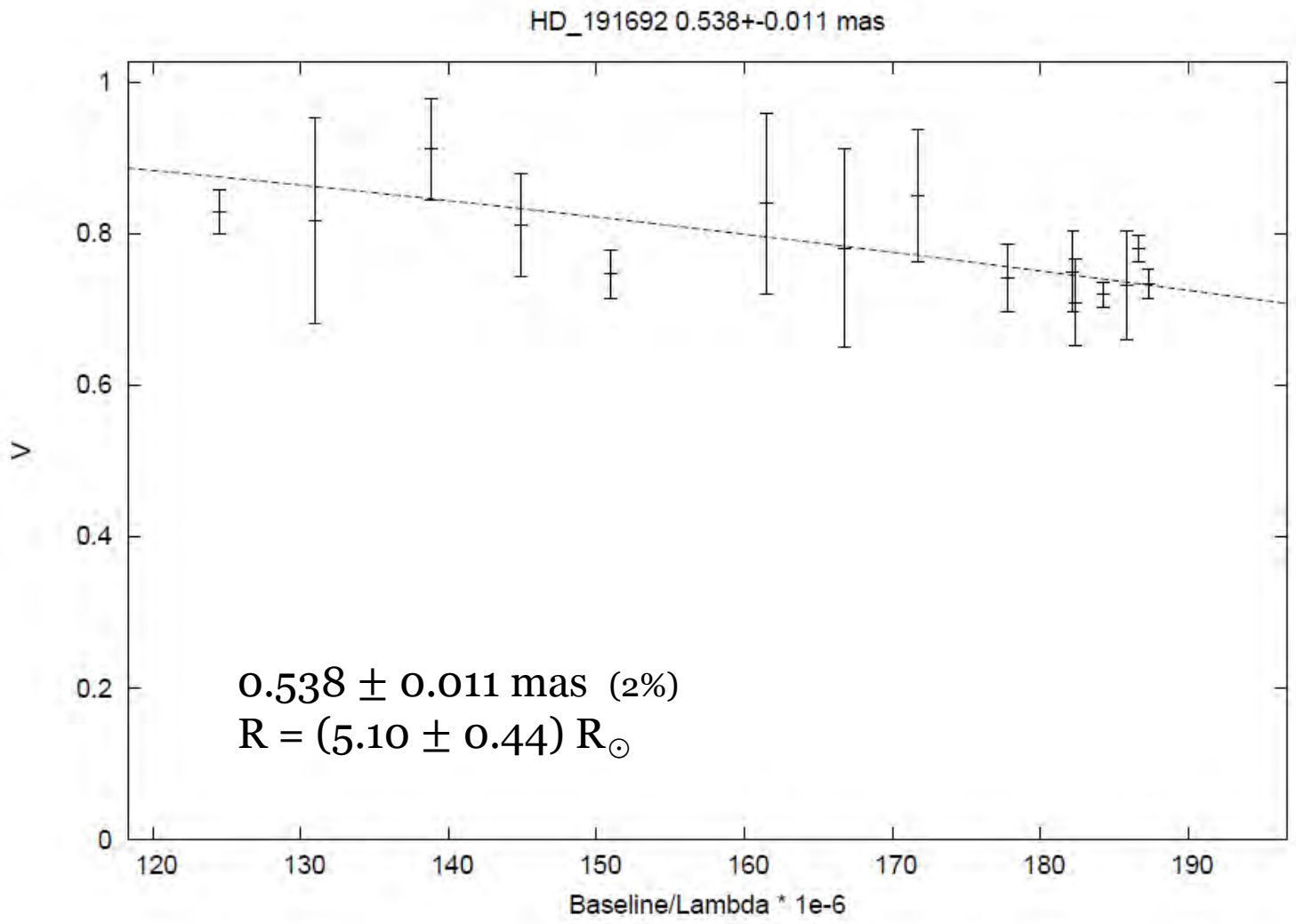


0.450 ± 0.025 mas (6%)

$R = (3.09 \pm 0.23)\ R_{\odot}$

B8 V **V=3.4** **~64 pc**

HD 191692 (5 brackets)



0.538 ± 0.011 mas (2%)

$R = (5.10 \pm 0.44)\ R_{\odot}$

B9.5 III **V=3.23** **~88pc**

What's next?

- **More data!**
- **Physical size → effective temperature (spectrophotometry) → luminosity**
- **With luminosity and temperature we can place our stars on HR diagram using observed values**
- **Test evolutionary models**


Questions?

Image Credits

(1) http://sci.esa.int

(2) Tobiska, W.K. et al., 2000. Journal of Atmospheric and Solar-Terrestrial Physics 62, 1233.

(3) http://scienceblogs.com/startswithabang/2010/07/22/the-biggest-star-weve-ever-fou/

(4) http://minsex.blogspot.com/2010/11/binary-star-ogle-lmc-cep0227.html

(5) http://www.mpl3d.com/solar.htm

(6) http://www.sciencedaily.com/releases/2010/05/100519092704.htm