Effective Temperatures and Angular Diameters of B Stars – Results!

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O stars (6): Gordon, K.D., Gies, D.R., Schaefer, G.H., et al. 2018, ApJ, 869, 37

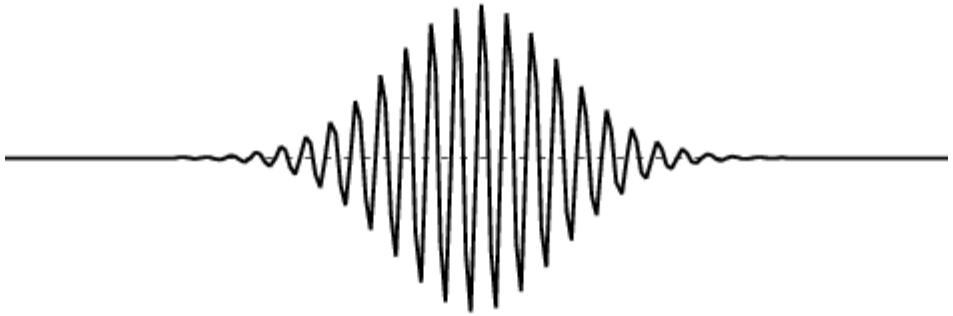
B stars (25): Gordon, K.D., Gies, D.R., Schaefer, G.H., et al. 2019, ApJ, 873, 91

Overall goal:

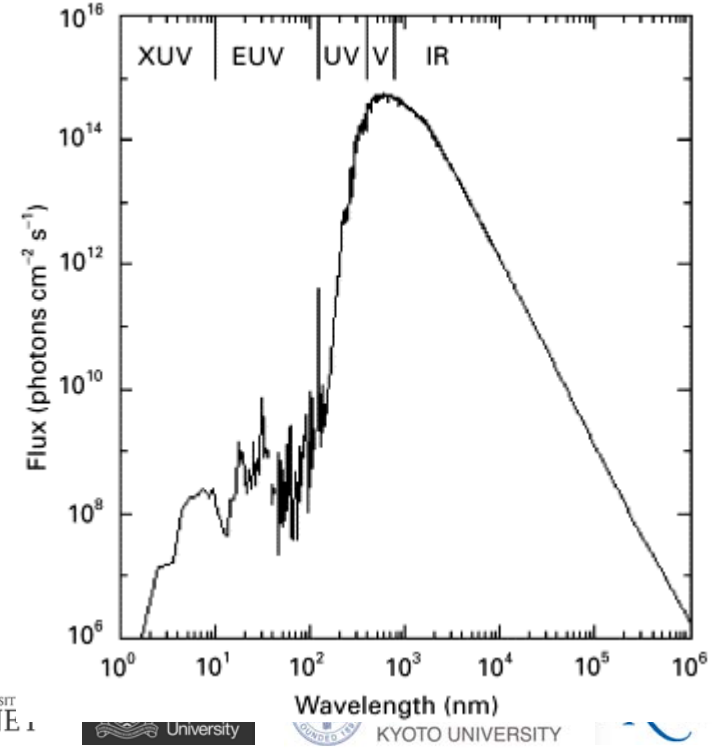
- Use angular diameters from CHARA to observationally determine fundamental parameters (radius and temperature) for O and B stars
- Place stars on an *observational* HR diagram

How do we get observationally determined properties?

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



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



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

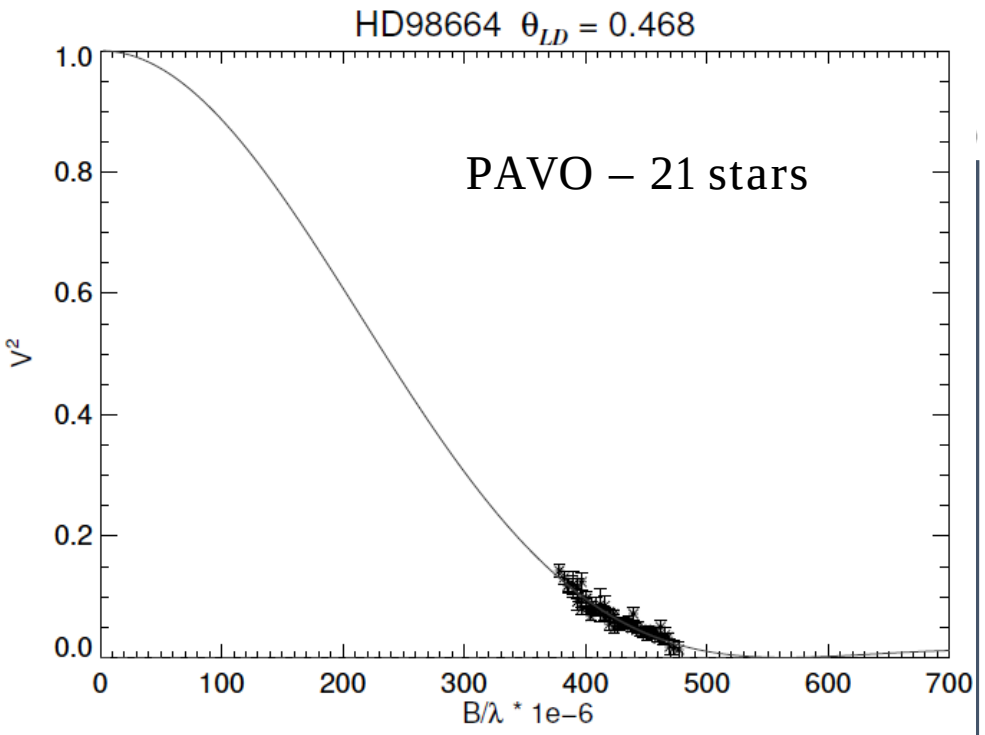
Our Sample

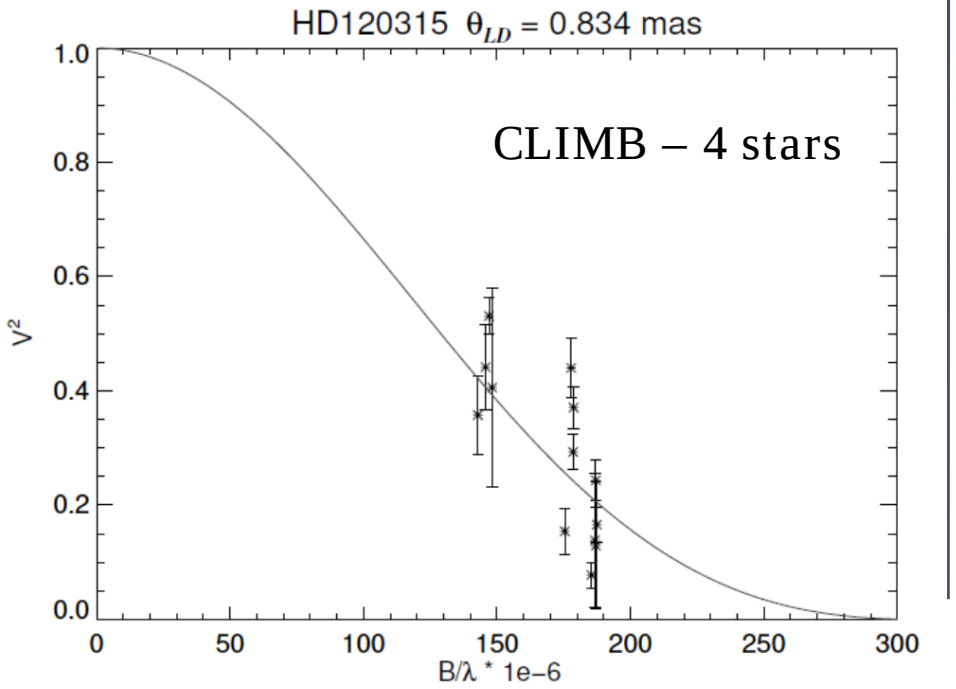
- 25 B-type stars
- B 1 to B 9.5
- 1 supergiant, 14 giants, 10 dwarfs
- 3 Pleiades members
- 32 pc – 1,177 pc

- 0.200 – 1.090 mas

Visibility fitting

- Data fit with an error weighted single star, linear limb-darkened disk model
- Limb-darkening coefficients interpolated from Claret et al., 2011
- 9 stars corrected for incoherent flux from a companion
- 1 star (HD 23850) fit as a binary (thanks Gail!)





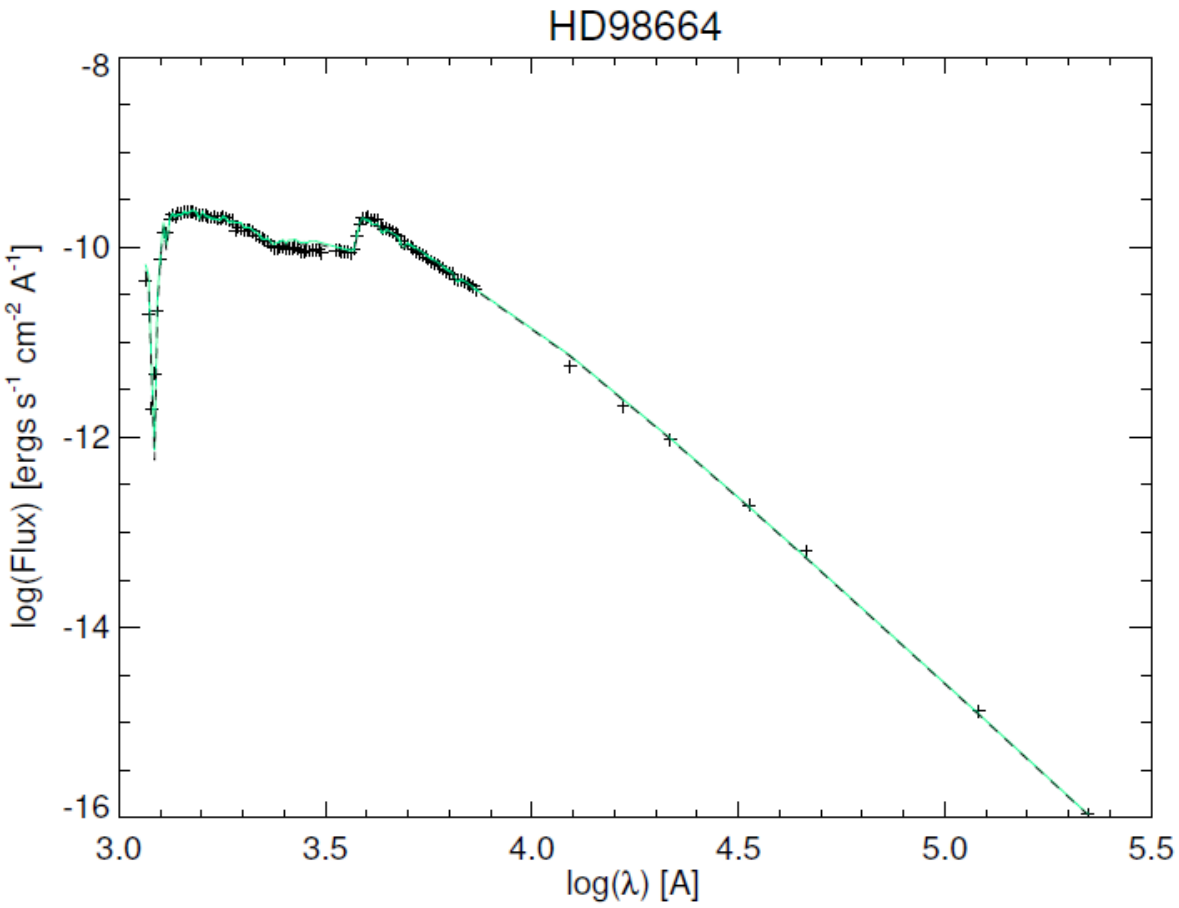
Spectrophotometric Modeling

- Fit observed spectra with atmospheric models
  - TLUSTY B star models and ATLAS9 models

- UV from IUE (1150-3347 Å) or UV Bright Star Spectrophotometric Catalog (1360 – 2740 Å)

- Optical from Burnashev et al., 1985 (3200-8175 Å) (most stars)

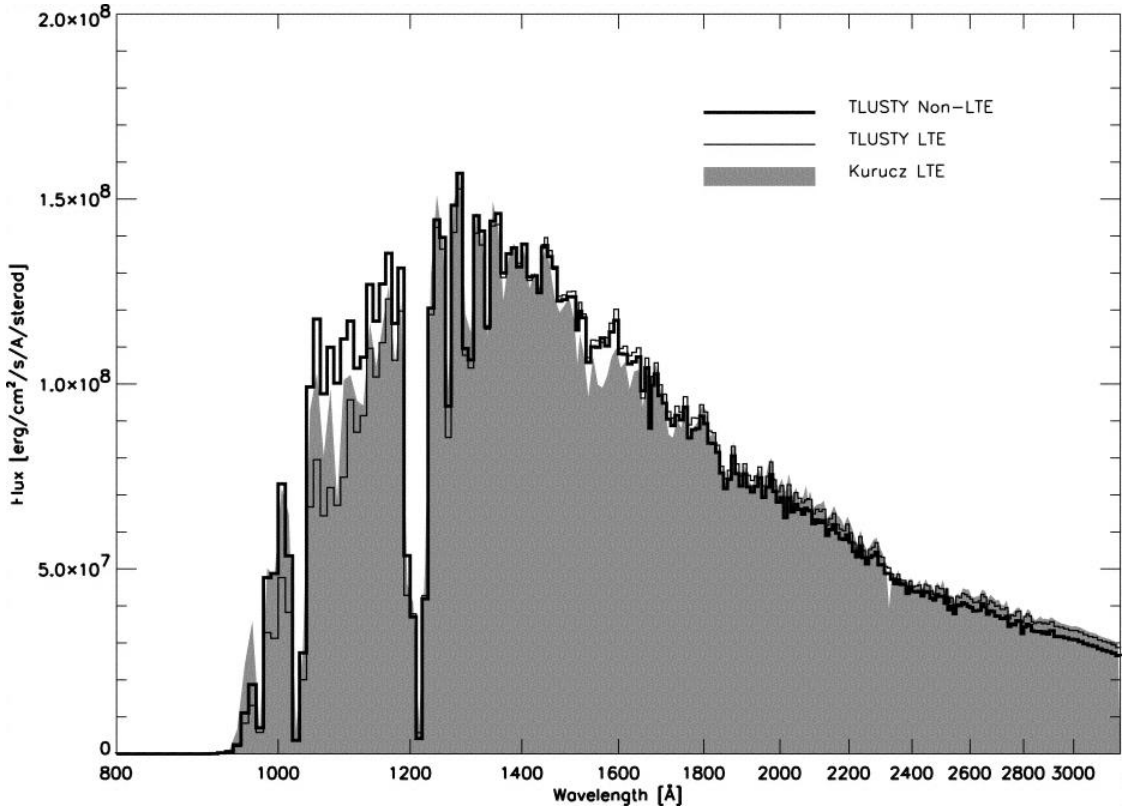
- IR from 2MASS and WISE



Models

- **TLUSTY B star:** non-LTE,
  line blanketed, plane parallel
  15,000 to 30,000 K
  log *g* = 1.75 to 4.75
  Solar metallicity
  v_t=2 km s^{-1}

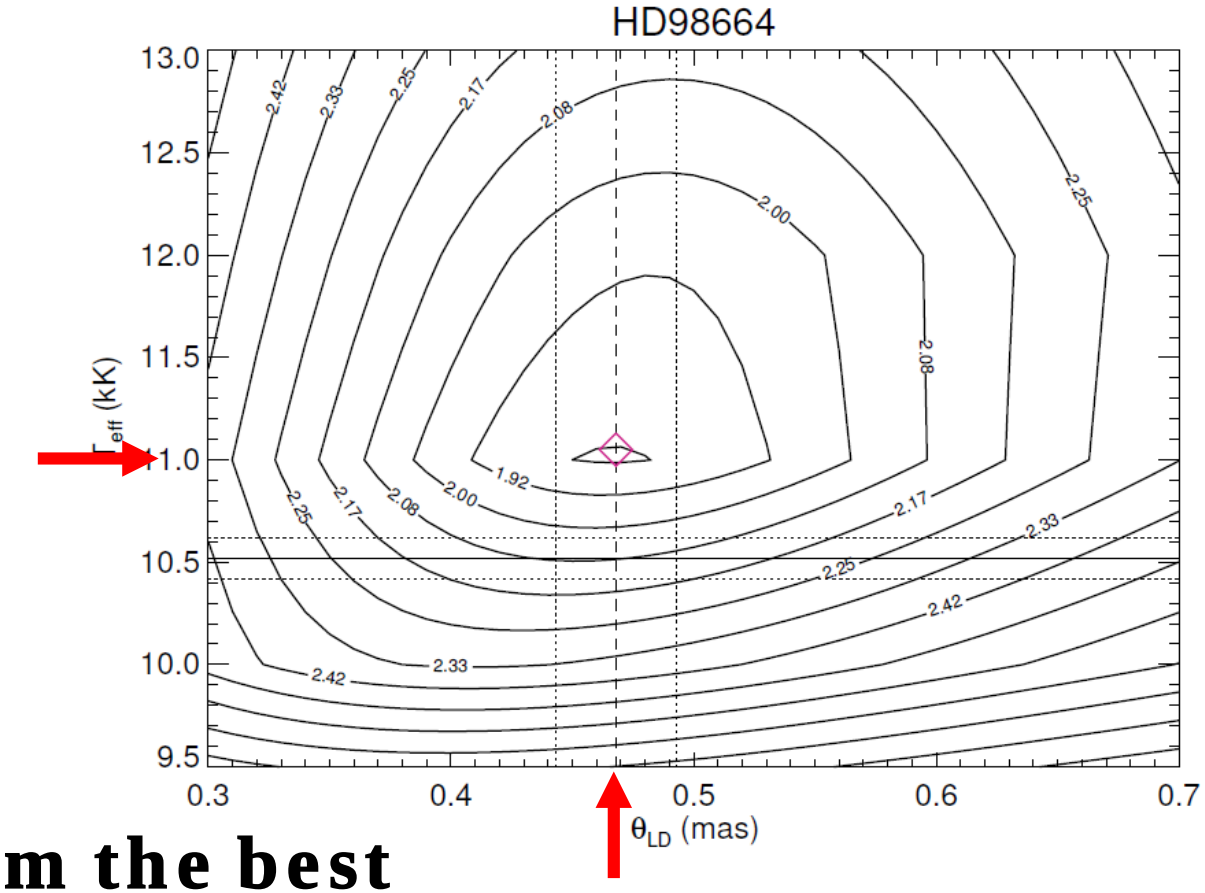
- **ATLAS9:** LTE, plane parallel
  3,500 to 50,000 K
  (our range 5,000 to 20,000 K)
  log *g* = 0.0 to 5.0
  Solar metallicity
  v_t=2 km s^{-1}



Morales et al., 2001

Model Fitting

- **Grid search method based on three parameters:**
  - **angular size θ_{LD}**
  - **effective temperature T_{eff}**
  - **reddening E(B - V)**



- **Contour maps: χ^2 matrix from the best fit E(B - V) as a function of T_{eff} and θ_{LD}**

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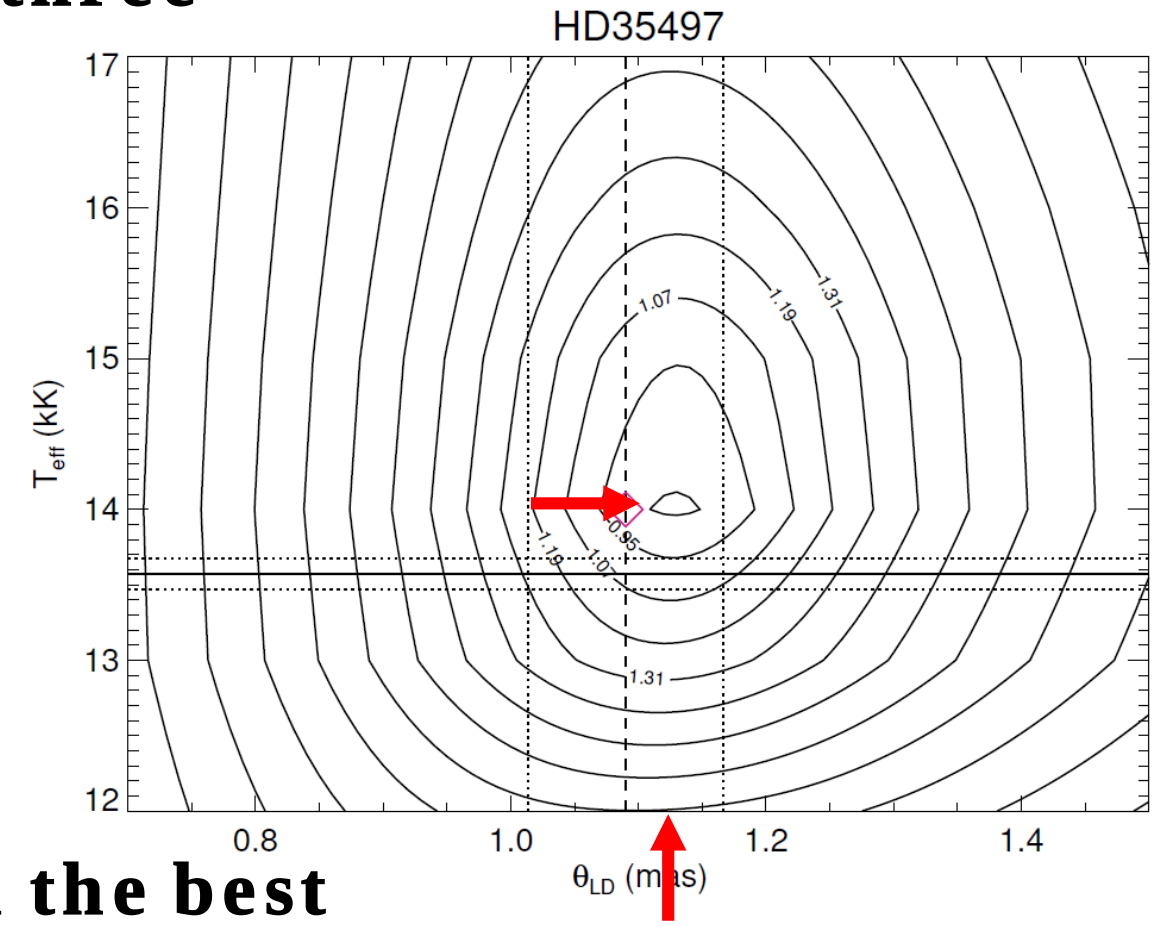

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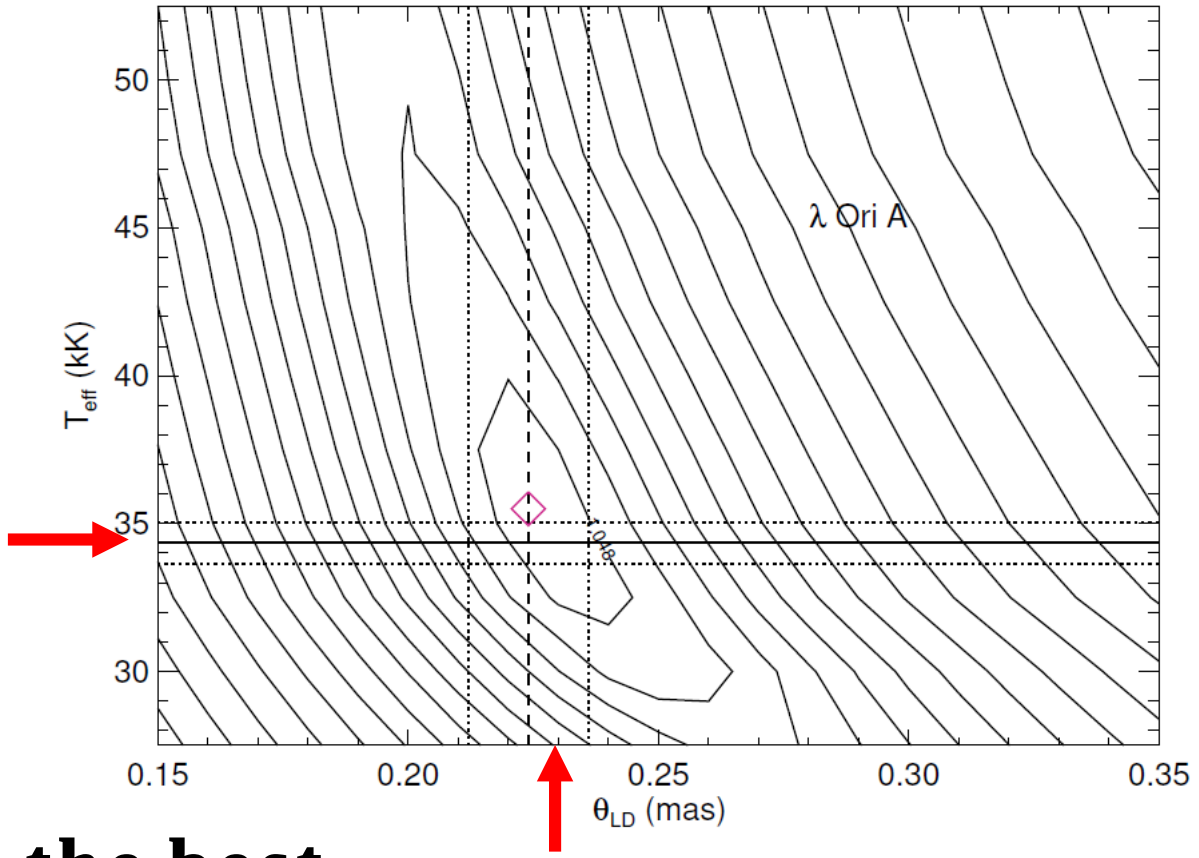

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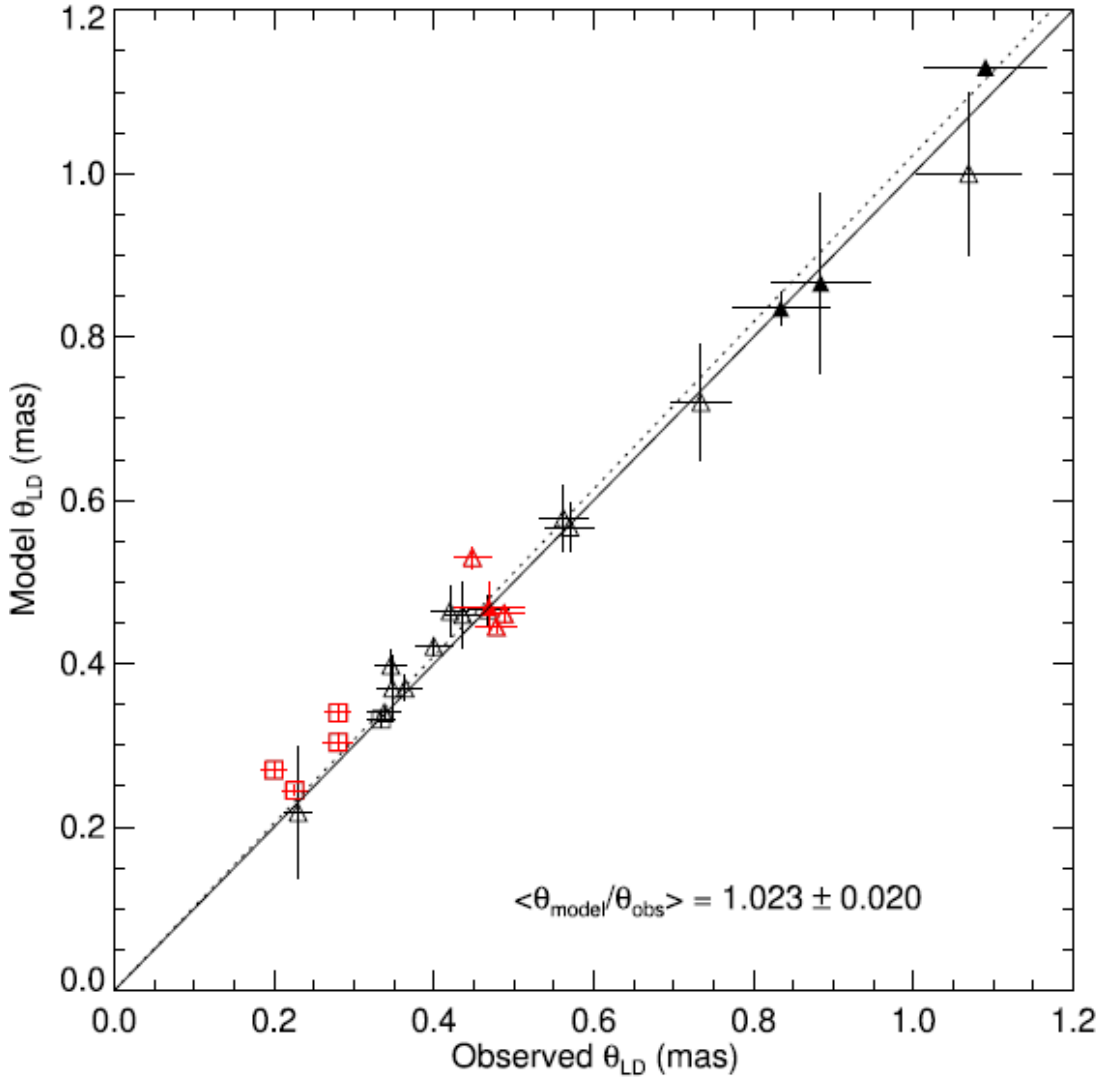
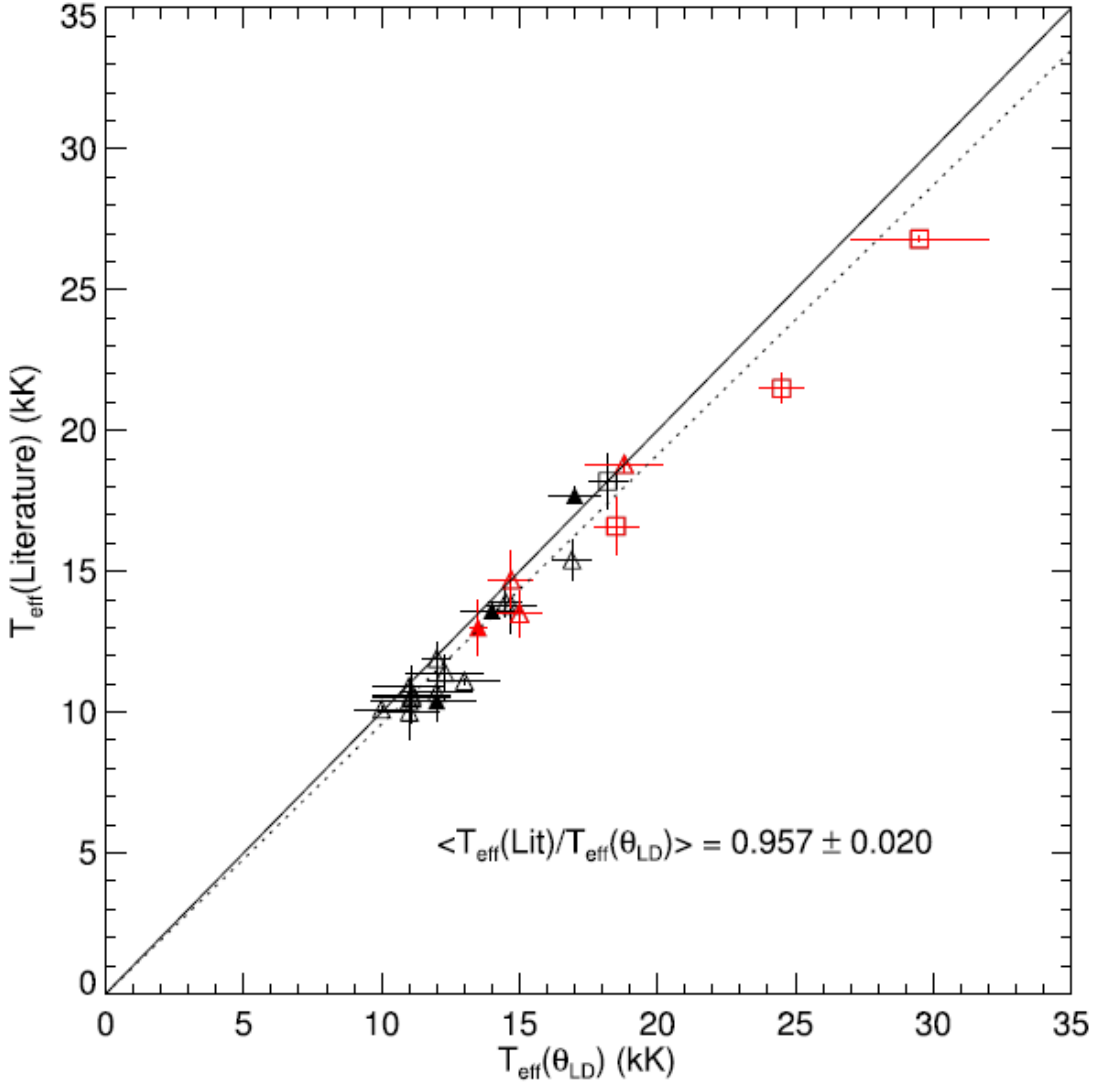
Results

Diameters in good agreement with models; temperatures underestimated by literature by ~4%



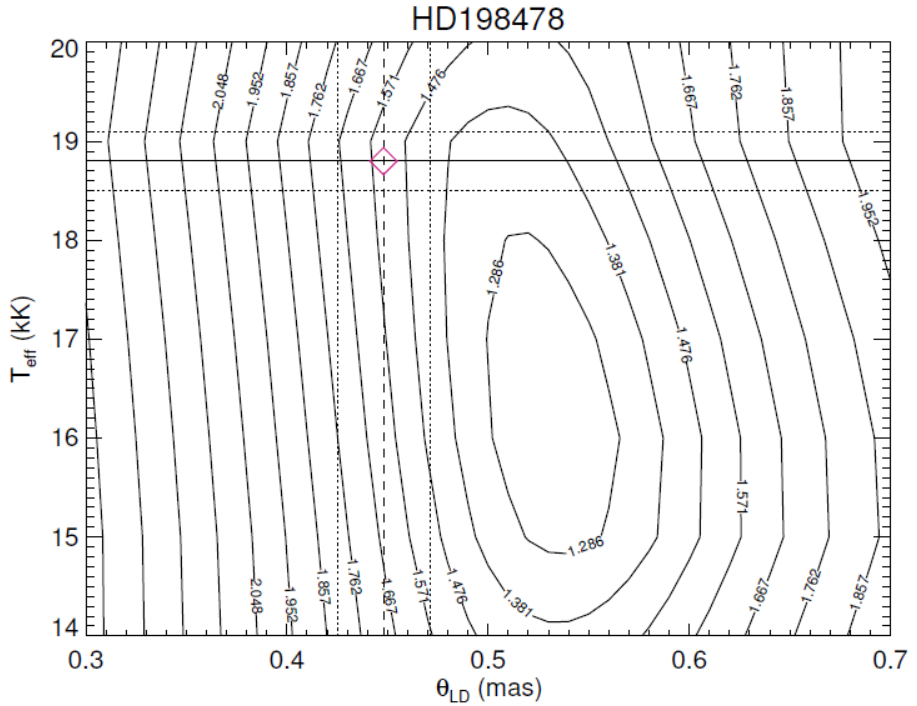


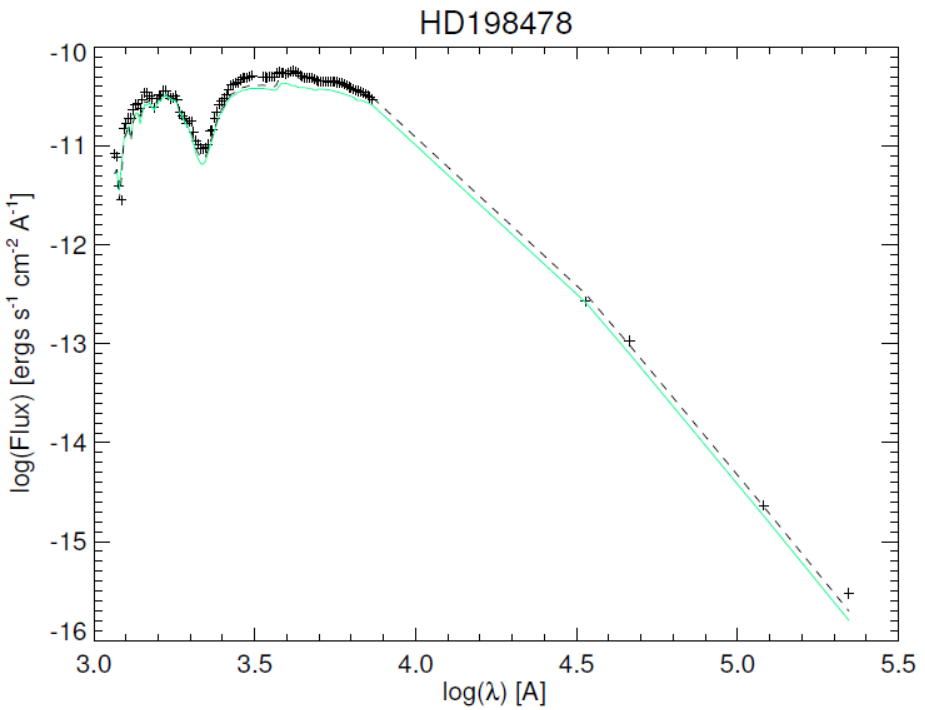
Gordon et al. 2019

55 Cyg

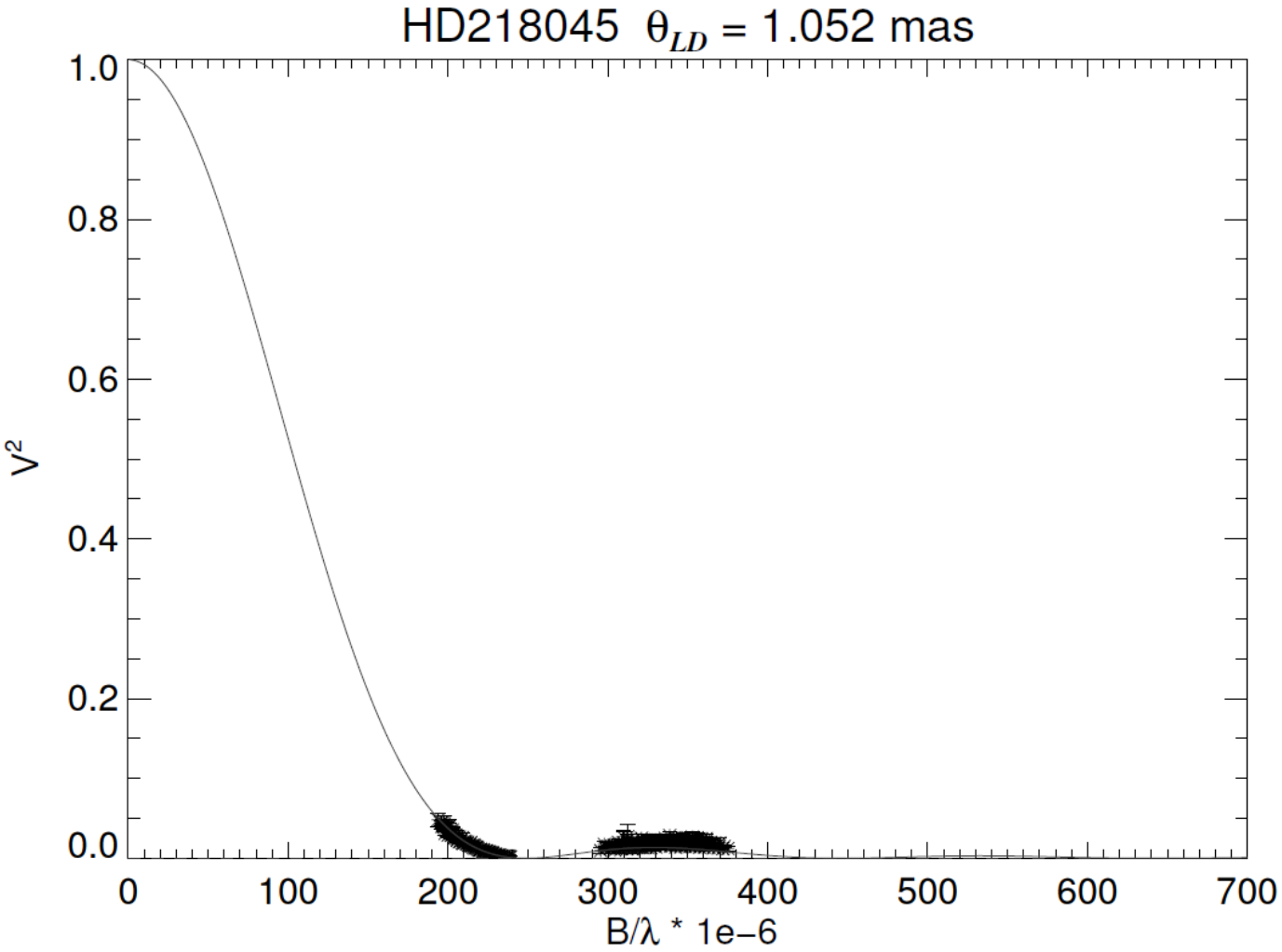
- B3Ia
- 1,177 pc (Gaia DR2)
- $\theta_{LD}=0.448\pm0.023$ mas
- $T_{eff}=18.8$ kK

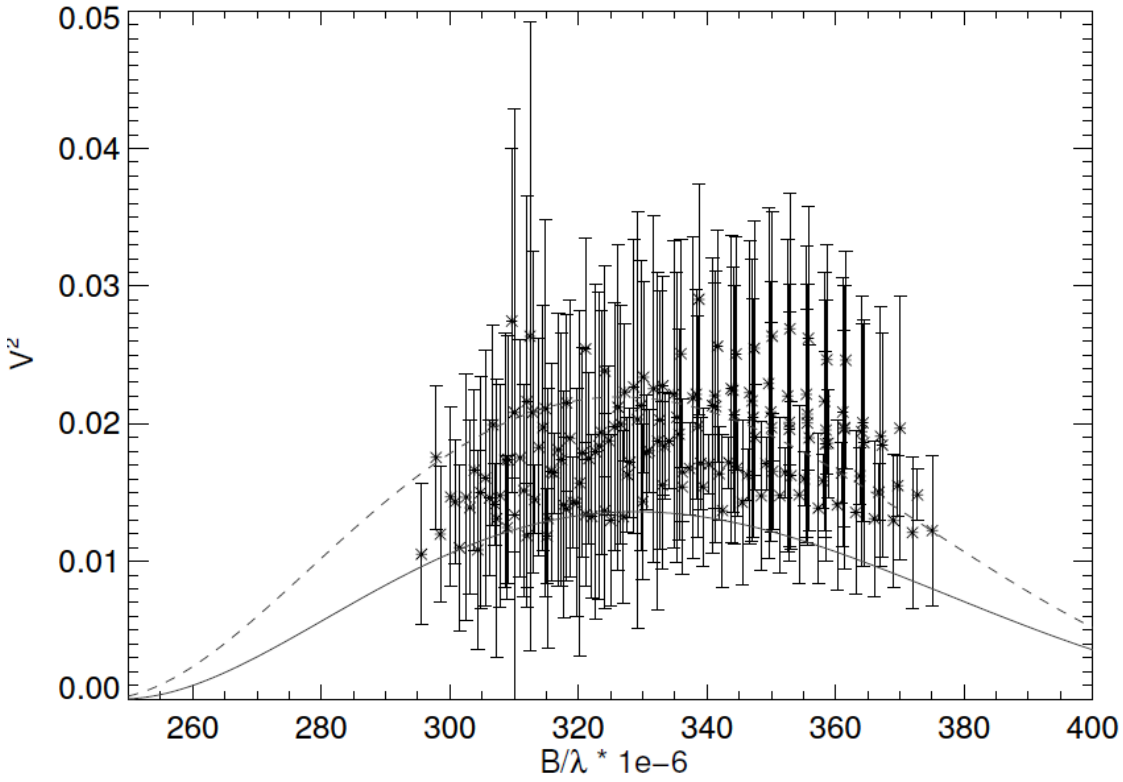
- Kraus et al. 2015 – modelled spectra with FASTWIND code
- $T_{eff}=18.8$ kK
- $R=57R_{\odot}$ → 0.45 ± 0.07 mas



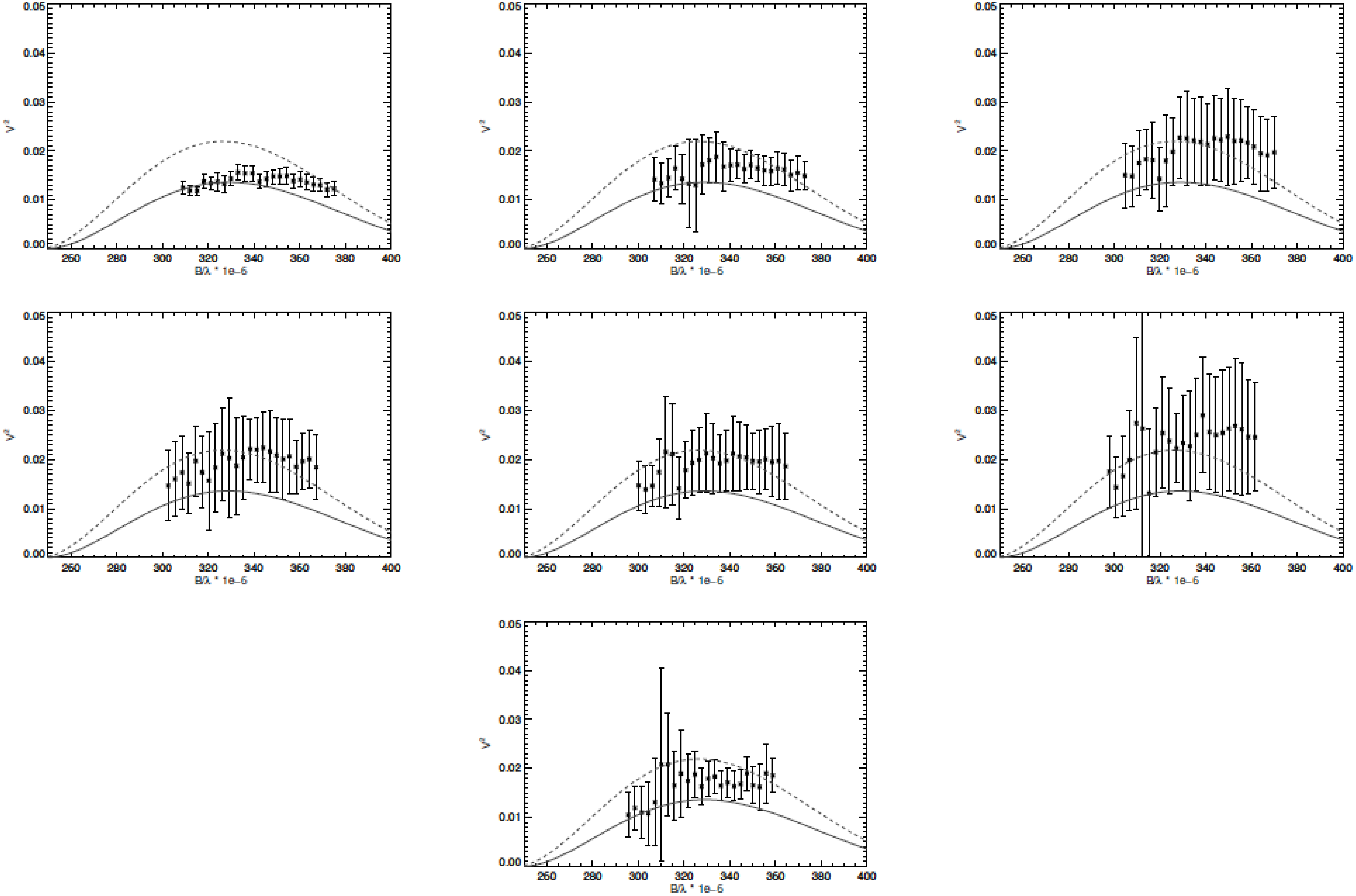


α Peg (Markab)





μ=0.34


0.05
0.04
0.03
0.02
0.01
0.00
V^2
260 280 300 320 340 360 380 400
B/λ * 1e-6

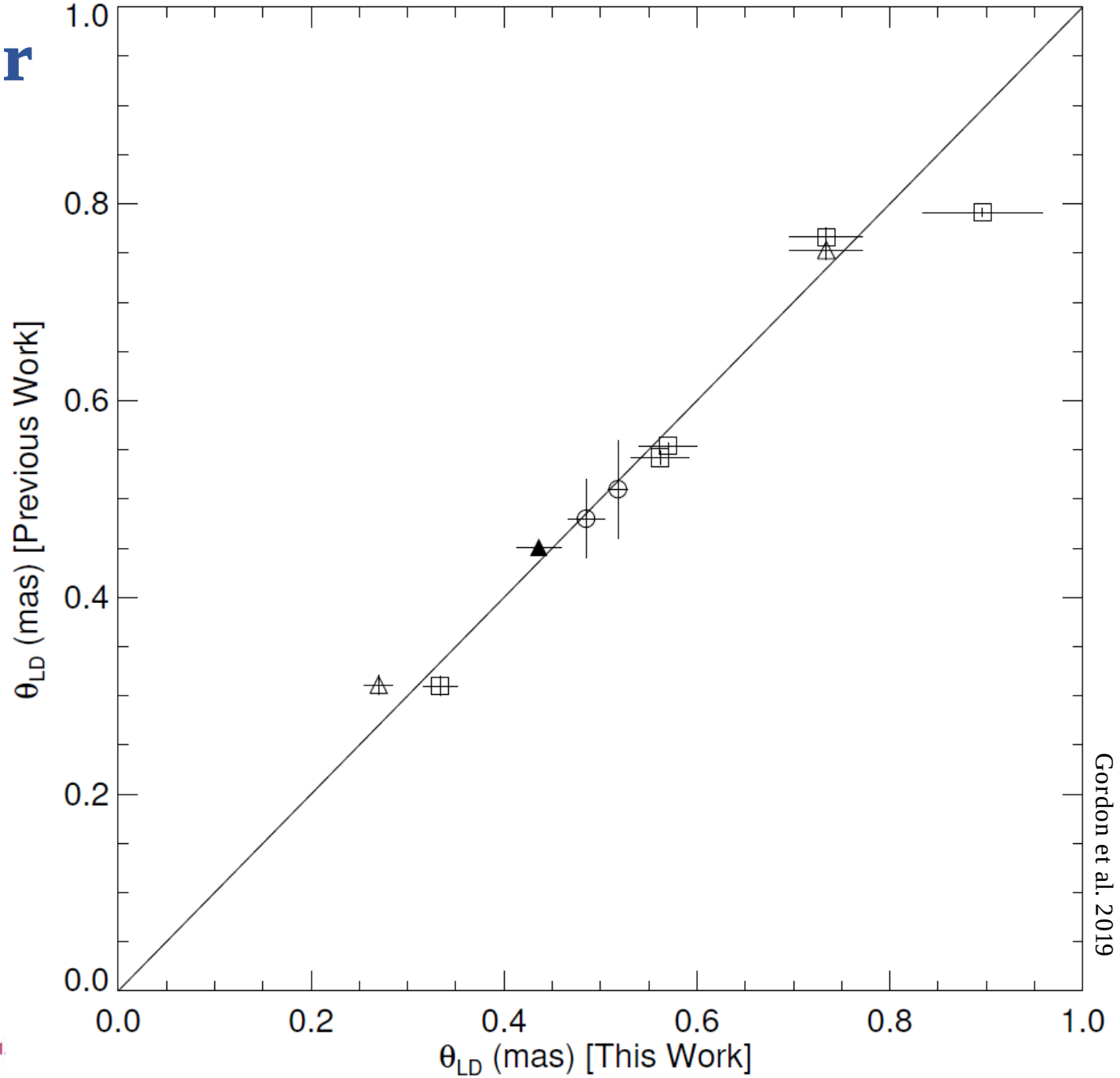
Putting it all together

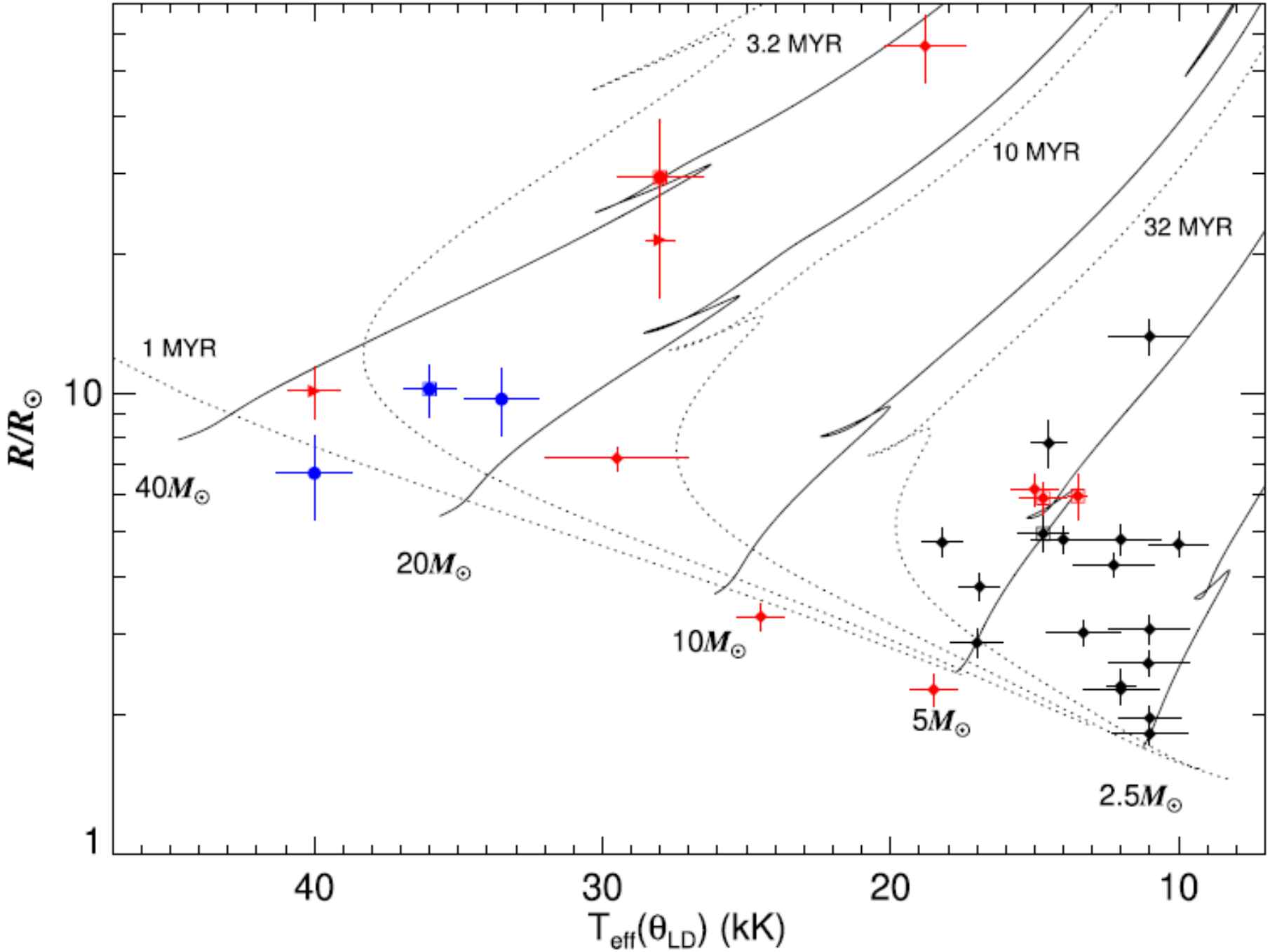
= VEGA observations by Challouf et al. (2014)

= NSII observations by Hanbury Brown et al. (1974)

= PAVO observation by White et al. (2017)

= PAVO observations by Maestro et al. (2013)





Gordon et al. 2019

Future Work

- Expand sample
- Investigate B supergiants – how important are winds?


Questions?