Fundamental Properties of O- and B-type Stars

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WHY DO WE CARE?
OUR SAMPLE

- Started with: 10 O stars, 189 B stars
  ~0 to 5 mag
  In or near galactic plane

- Narrowed down to: 10 O stars, 67 B stars
  Use all O stars
  B stars with Hipparcos parallax errors < 10%
  Cluster member
  No Be stars
Closest O star: zeta Oph (HD 149757) - 140±14 pc
Farthest O star: alpha Cam (HD 30614) - 1900±700 pc

Closest B star: alpha And (HD 358) – 29.8±0.6 pc
Farthest B star: gamma Lyr (HD 176437) - 195±19 pc

8 B stars within 50 pc
37 B stars within 100 pc
30 B stars > 100 pc

Expected sizes: 0.2 – 1.4 mas

V: 48%    IV: 17%    III: 27%    II: 5%    I: 3%
• Many massive stars are in binary or multiple star systems! (opportunity?)

• Not many stars nearby → smaller angular sizes

• Working close to resolution limits of CHARA

• Good calibrators harder to find
OUR GOALS

• Radius, temperature, mass, age

• Model dependent!
  • Color and spectra
  • Large errors in luminosity
Observationally determined properties

- Angular size + distance → Radius
  » Interferometry

- Integrated flux + angular size → Effective Temperature
  » Spectrophotometry

\[ F_{\text{obs}} = \frac{1}{4} \alpha^2 F_{\text{em}} \quad F_{\text{em}} = \sigma T_{\text{eff}}^4 \]
4 stars in our sample overlap
DATA AND RESULTS SO FAR

Nights scheduled: 66
(from 2012-2015)

Nights with data: 22

Data on 33 stars

Diameters for 27 stars (2 O stars – alpha Cam and HD 214680)
\(\lambda\) Ori

April 2014

November 2013

Spatial Frequency (rad\(^{-1}\))

\(v^2\)
COMPARING CLIMB AND PAVO

$1.028 \pm 0.003$

7%
0.560 ± 0.008
Companion adding extra light to visibility curve

54%

$0.445 \pm 0.010$
Table 4. Measured angular diameters and fundamental properties.

<table>
<thead>
<tr>
<th>Star</th>
<th>Combiner</th>
<th>( \mu )</th>
<th>( \theta_{UD} ) (mas)</th>
<th>( \theta_{LD} ) (mas)</th>
<th>( R ) (R( \odot ))</th>
<th>( M ) (M( \odot ))</th>
<th>( T_{\text{eff}} ) (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \theta ) Cyg</td>
<td>PAVO</td>
<td>0.47 ± 0.04</td>
<td>0.720 ± 0.004</td>
<td>0.754 ± 0.009</td>
<td>1.49 ± 0.02</td>
<td>1.37 ± 0.04</td>
<td>6745 ± 44</td>
</tr>
<tr>
<td></td>
<td>MIRC</td>
<td>0.21 ± 0.03</td>
<td>0.726 ± 0.014</td>
<td>0.739 ± 0.015</td>
<td>1.46 ± 0.03</td>
<td>1.31 ± 0.06</td>
<td>6813 ± 72</td>
</tr>
<tr>
<td></td>
<td>PAVO+MIRC</td>
<td>–</td>
<td>–</td>
<td>0.753 ± 0.009</td>
<td>1.48 ± 0.02</td>
<td>1.37 ± 0.04</td>
<td>6749 ± 44</td>
</tr>
<tr>
<td>16 Cyg A</td>
<td>PAVO</td>
<td>0.54 ± 0.04</td>
<td>0.513 ± 0.004</td>
<td>0.539 ± 0.006</td>
<td>1.22 ± 0.02</td>
<td>1.07 ± 0.04</td>
<td>5839 ± 37</td>
</tr>
<tr>
<td></td>
<td>Classic</td>
<td>0.26 ± 0.04</td>
<td>0.542 ± 0.015</td>
<td>0.554 ± 0.016</td>
<td>1.26 ± 0.04</td>
<td>1.16 ± 0.10</td>
<td>5759 ± 85</td>
</tr>
<tr>
<td></td>
<td>PAVO+Classic</td>
<td>–</td>
<td>–</td>
<td>0.539 ± 0.007</td>
<td>1.22 ± 0.02</td>
<td>1.07 ± 0.05</td>
<td>5839 ± 42</td>
</tr>
<tr>
<td>16 Cyg B</td>
<td>PAVO</td>
<td>0.56 ± 0.04</td>
<td>0.467 ± 0.004</td>
<td>0.490 ± 0.006</td>
<td>1.12 ± 0.02</td>
<td>1.05 ± 0.04</td>
<td>5809 ± 39</td>
</tr>
<tr>
<td></td>
<td>Classic</td>
<td>0.27 ± 0.04</td>
<td>0.502 ± 0.020</td>
<td>0.513 ± 0.020</td>
<td>1.17 ± 0.05</td>
<td>1.20 ± 0.14</td>
<td>5680 ± 112</td>
</tr>
<tr>
<td></td>
<td>PAVO+Classic</td>
<td>–</td>
<td>–</td>
<td>0.490 ± 0.006</td>
<td>1.12 ± 0.02</td>
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<td>5809 ± 39</td>
</tr>
</tbody>
</table>

White et al., 2013
LIMB DARKENING DATA

HD 218045

Spatial Frequency (rad⁻¹)
FUTURE WORK

• Finish observations this year

• Combine spectrophotometry with interferometric sizes

• Fit binaries well and still get star sizes

• Fit data with one routine to help normalize and understand errors

• Place stars on evolutionary tracks and compare with models
Questions?
http://sci.esa.int
