Sizing up the Stars

Main Sequence Stellar Diameters with the CHARA Array

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Outline

• Why measure stellar diameters?
• My thesis project overview
• Current status / results
• Grad student winter observing status
First of all, Size DOES Matter!!!

- If you are thirsty…

http://homebarsupplys.com/images/products_fullsize/ultimate_mug_1.jpg
Size DOES Matter!!!

- If you are clothes shopping…

www.svrc.vic.edu.au/02
Size DOES Matter!!!

• If you are choosing a guard dog...

http://www.dognet.biz/big_dog_little_dog.jpg
Size DOES Matter!!!

- If you are stuck in the mud…

http://www.humvee.net/pix/ramstkh.jpg
Size DOES Matter!!!

• If you need to park your car…

Size DOES Matter!!!

• In Stellar Astronomy, size does matter too!
  – Effective temperature
  – Absolute luminosity
  – Constraints for model stellar atmospheres and evolution
  – Single VS binary star radii (from eclipsing binaries)
  – Metallicity and age
  – Rotation

• Direct diameter measurements with long baseline optical (IR) interferometry of a large sample of stars, enables us to derive relationships (e.g., with photometry) to characterize an even larger number of stars, too far away (small) to observe with interferometry.
My Thesis

Angular Diameters of Main Sequence A, F, and G stars with the CHARA Array

• Who:
  – Advisor: Hal McAlister
  – Committee: Doug Gies, Todd Henry, Nikolaus Dietz, Paul Wiita, Gerard van Belle
Goals

• Better than 4% accuracy in diameter
  – Establish effective temperature scale < 2% error
  – Absolute luminosity → HR diagram
  – Testing stellar evolution models
    • Metallicity and age
    • Duplicity
  – Rotation
Target Selection

- Target sample was limited by:
  - Better than 4% accuracy on diameter determination from visibility curve
- A, F, and G star *Hipparcos* query

<table>
<thead>
<tr>
<th>Spectral Type</th>
<th>V mag</th>
<th>B-V</th>
<th>Distance (pc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0 V – A5 V</td>
<td>6.0</td>
<td>-0.02 – 0.15</td>
<td>&lt; 33</td>
</tr>
<tr>
<td>A6 V – F0 V</td>
<td>6.4</td>
<td>0.15 – 0.30</td>
<td>&lt; 29</td>
</tr>
<tr>
<td>F1 V – F5 V</td>
<td>6.7</td>
<td>0.30 – 0.44</td>
<td>&lt; 25</td>
</tr>
<tr>
<td>F6 V – G0 V</td>
<td>7.0</td>
<td>0.44 – 0.58</td>
<td>&lt; 21</td>
</tr>
<tr>
<td>G1 V – G5 V</td>
<td>7.3</td>
<td>0.58 – 0.68</td>
<td>&lt; 17</td>
</tr>
<tr>
<td>G6 V – K0 V</td>
<td>7.5</td>
<td>0.68 – 0.81</td>
<td>&lt; 16</td>
</tr>
</tbody>
</table>
Target Selection

• Other limiting factors to qualify:
  – Duplicity (separation of $2<\rho<5$ mas flagged)
  – Rotation (flagged)
  – Abnormal atmospheric activity

• Rough sample size of 92 stars
Observations

- CHARA Classic; K and H band
- Baselines; S1/E1 and S1/W1 or E1/W1
- SED fits for Calibrators and Targets
- Limb darkened diameter fits from visibility curve
Results so far..

**HD 97603: A4V;**
LD = 2.53 +/- 0.06 M☉

**HD 222368: F7V;**
LD = 1.77 +/- 0.02 M☉
Results so far..

HD 19373: G0V;
LD = 1.41 ±/− 0.02 M⊙

Baseline (mlambda)
Visibility

LIMB DARKENED DISK FIT

mDiamL: 1.248
σmDiamL: 0.016
σresL: 0.012
wmDiamL: 1.248
σwmDiamL: 0.016

HD 34411: G0V;
LD = 1.41 ±/− 0.05 M⊙

Baseline (mlambda)
Visibility

LIMB DARKENED DISK FIT

mDiamL: 1.035
σmDiamL: 0.038
σresL: 0.032
wmDiamL: 1.022
σwmDiamL: 0.035
Results so far..

HD 22484: F9V;
LD = 1.70 +/- 0.03 M☉

HD 102870: F9V;
LD = 1.74 +/- 0.03 M☉
Procyon

![Graphs showing data for Procyon with two plots comparing uniform and limb darkened disk fits.](image)
Grad Winter Observing Progress

- 2007 January – 2007 March: ~16 days
- AROC Observers: Ellyn, Tabetha, and Deepak
- Mt Wilson: PJ and Chris (+ CHARA staff)
Grad Winter Observing Issues:
HVAC on makes tracking HARD

Summary of Results for:
HD = 56537    UTDate = (2007 2 25)    SeqNo = 1
UT = (3 49 35)    RA = (7 18 6)
LT = (21 49 35)    Dec = (16 32 25)
LST = 8.3039    LSTrange = 0.0333
HA = 1.00    HRange = 0.03
Alt = 67.76    Altrange = 0.27
Az = 41.06    Azrange = 1.04
U = 75.154    Urange = 1.775
V = 297.219    Vrange = 0.187
Scanlength = 558    Nscans = 205
lpass = 20    Rejects = 104
BW = 30    cutoff = 1.00
λ = 2.13E-006    range = 30
darkA = 61    darkB = 82
avIA = 844    avIB = 714
avBP = 151    σBP = 6
Freq0 = 155    DithStep = 0.333
avSel = 8.46    Baseline = 12

Results:
BY = 2007.15125
JD = 54156.7428
Vamp = 0.211
Vps = 0.260
σVis = 0.022
B = 306.579
Brange = 0.254
Θ = 75.810
Θrange = 0.330

MEAN FRINGE POWER SPECTRA
Red = Signal
Blue = Noise
Green = Dark
Black = Smoothed, Subtracted Signal

Visibility

(dots given zero wgt)
Grad Winter Observing Issues:
HVAC on makes tracking HARD and sometimes the Power spectrum is WEIRD!

Summary of Results for:

HD = 90840  UTD = (2007  1  23)  SeqNo = 3

UT = (9 6 40)  LT = (1 6 40)  LST = 9.4623
HA = 22.96  Alt = 76.64  Azm = 244.81
U = 168.271  V = 280.119  Scallength = 558
Urange = 2.387  Vrange = 1.845  Ipss = 20
B = 326.789  BW = 30  cutoff = 1.00
λ = 2.15E-006

Results:
BY = 2007.061273
JD = 54123.8796
Vamp = 0.256
Vps = 0.171
B = 326.789  Brange = 0.353
Θ = 59.006  Θrange = 0.525

MEAN FRINGE POWER SPECTRA
Red = Signal
Blue = Noise
Green = Dark
Black = Smoothed, Subtracted Signal

(dots given zero wgt)
Grad Winter Observing Issues:
PICO box vibrations in the lab?

Not always at same frequency, same shape, or same strength.
Comparing reduceIR and VisUV Calc: Tackling Noisy Data

• Noise subtracted signal is not perfect in using either software package

VisUV Calc:

Vibrations? (HVAC, and Vacuum are OFF)
Comparing reduceIR and VisUV Calc: Tackling Noisy Data

- When is the noise too close data to make it unusable?
Discussion

• Does one continue observing if these issues arise? (ie, should you be worried, or will reducing the data properly remove all noise)

• How do we improve the removal of such noise in data reduction?

• Should we make mandatory shut-off for HVAC, PICO and Vacuum for every run?

• Possibly add switches in control room to make it easier?