The Separated Fringe Packet Survey

Chris Farrington
CHARA / Mt. Wilson

March 2009

Collaborators:
T.A ten Brummelaar, N. Turner,
B. Mason, H. McAlister.

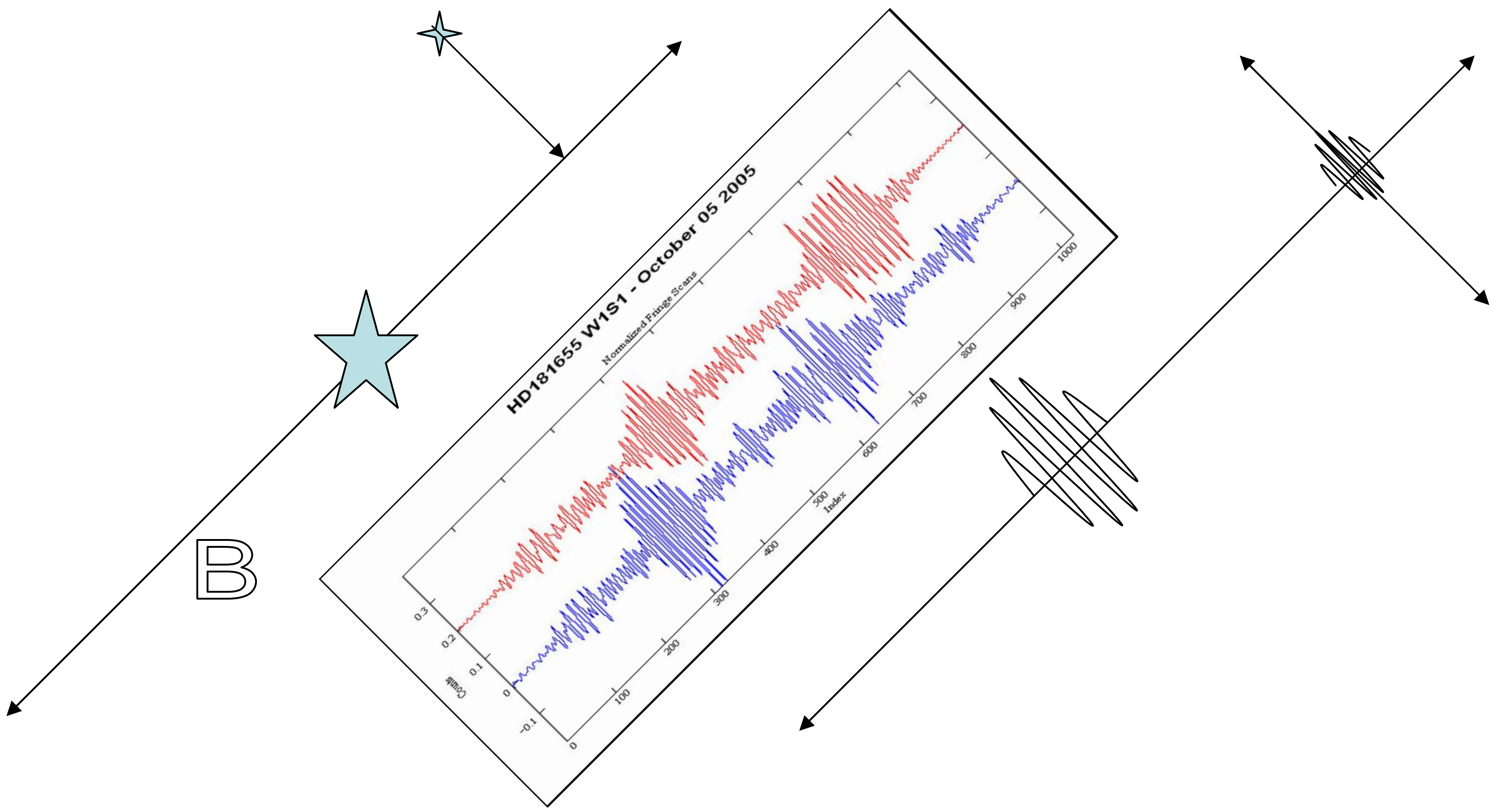
Discussion Topics

- Dissertation Survey
- Separated Fringe Packets
- Case Studies
  - HD 181655, 184467, 198084
- Utilizing Calibration
- Current and Future Plans
- Discussion

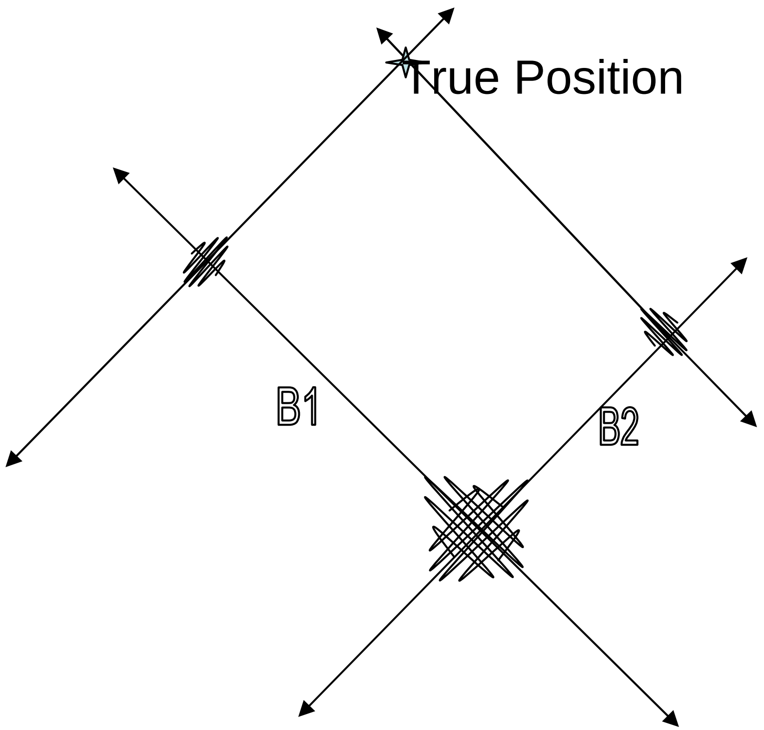
Observational Results

- 160 systems in the sample
  - 109 systems observed either on two baselines or more than 3 observations with more than 30˚ rotation.
  - 48 of the remaining systems were observed at least once without being observed on a complimentary baseline during the same run.
  - 3 systems were unable to be observed at all.
- 17 systems displayed SFP
  - 15 systems were in the CHARA Catalog of Spectroscopic binaries
  - 5 of these were also in the D&M survey
  - 2 completely new SFP systems with no previously known companion.
  - 7 systems never before angularly separated.

Vector Separation of Fringes

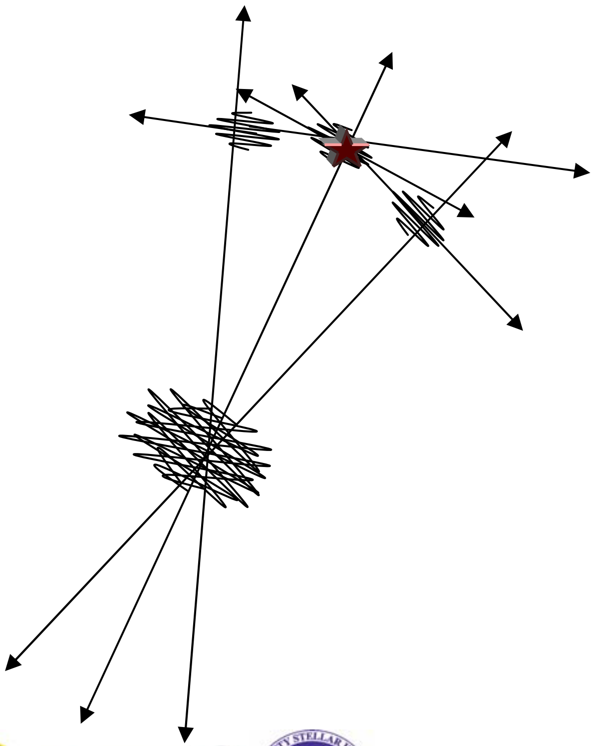


Ideal Case



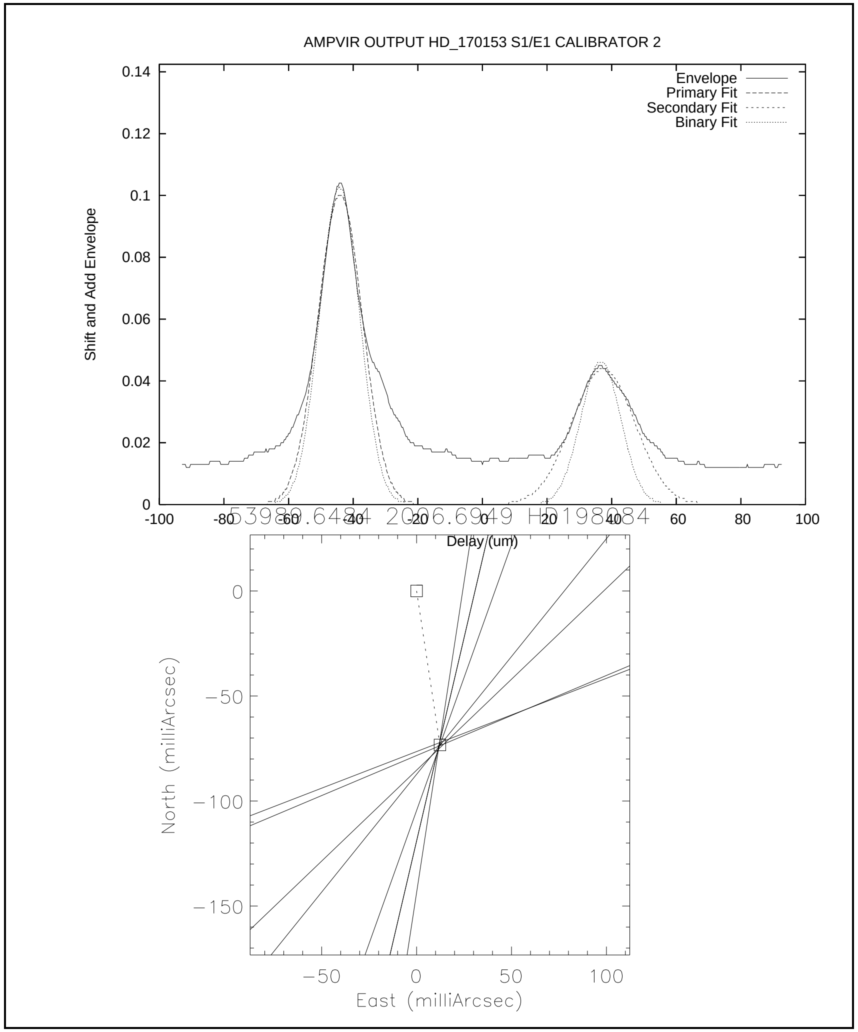
Also Acceptable

Nightly baseline rotation varies: 10-60°

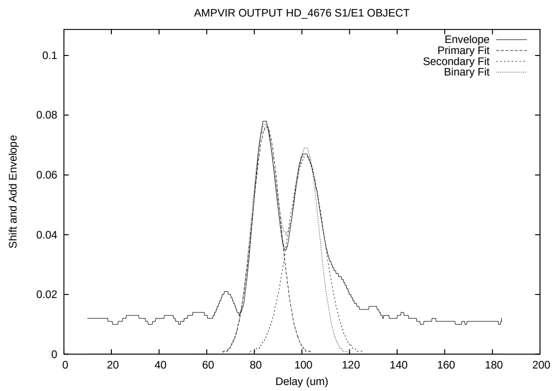


Calculating Fringe Separation

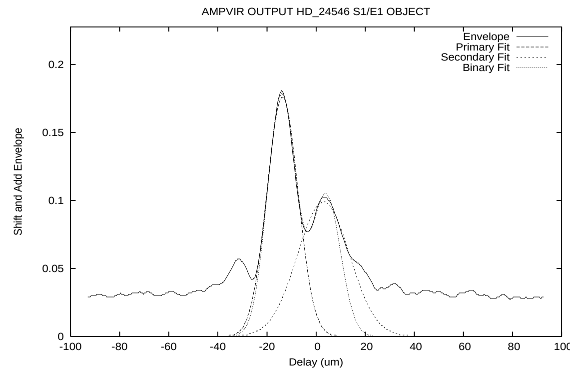
- Determining the primary packet
- Vector separation of the envelope peaks
  - $206.265\rho_{\mu m}/B(m)$
- Triangulation of the secondary from multiple files with rotation or perpendicular baselines.



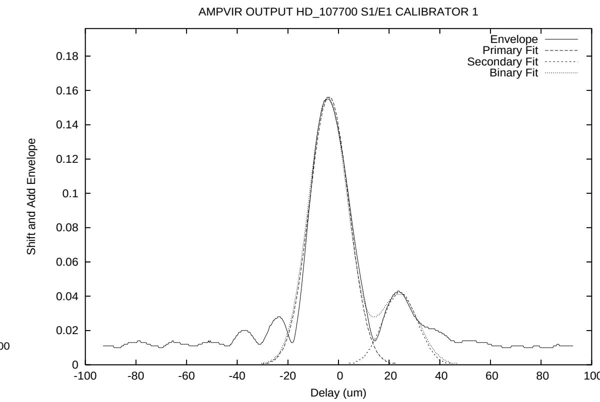
Separated Fringe Packet Systems



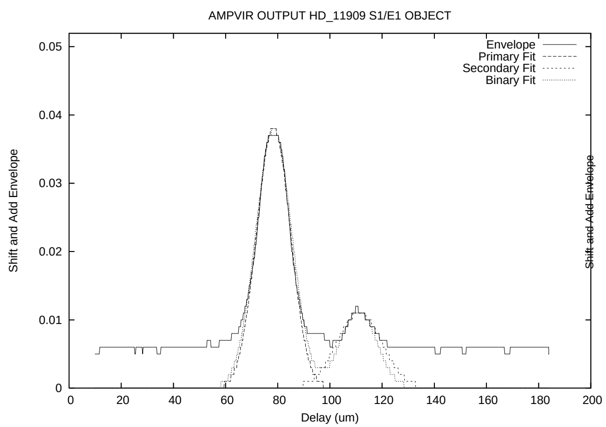
HD 4676



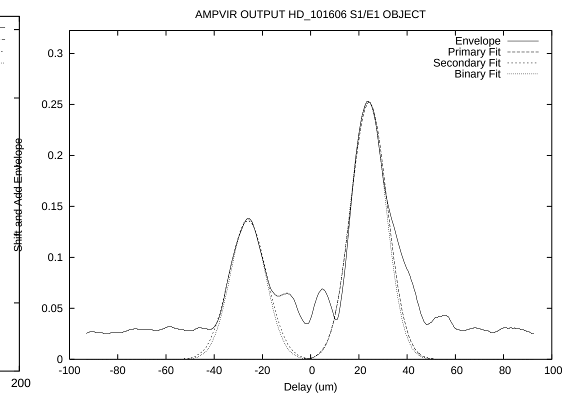
HD 24546



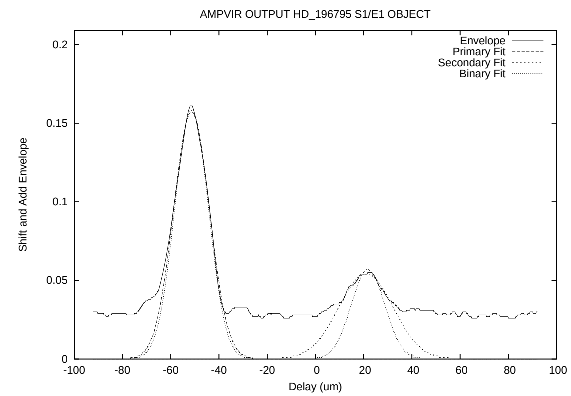
HD 107700



HD 11909

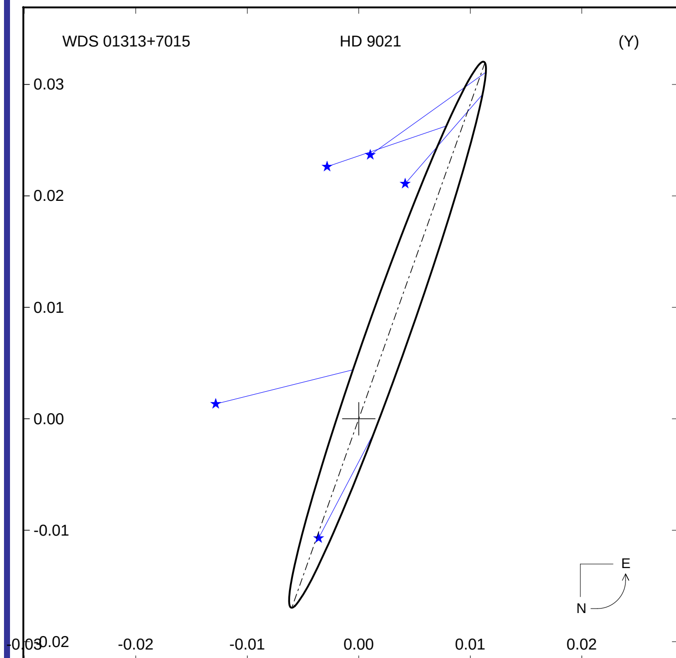


HD 101606



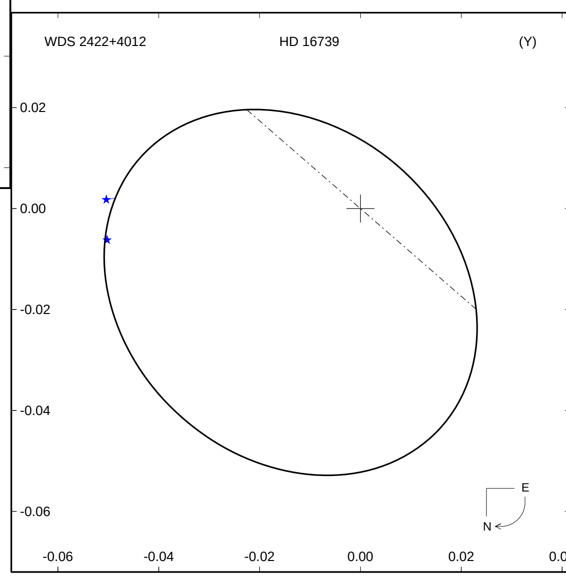
HD 196795

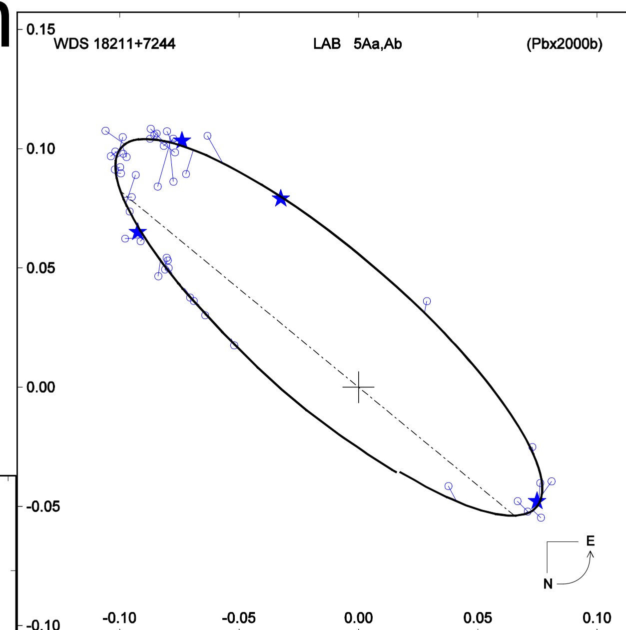
Separated Fringe Packet Systems with Triangulation



HD 9021

12 Persei

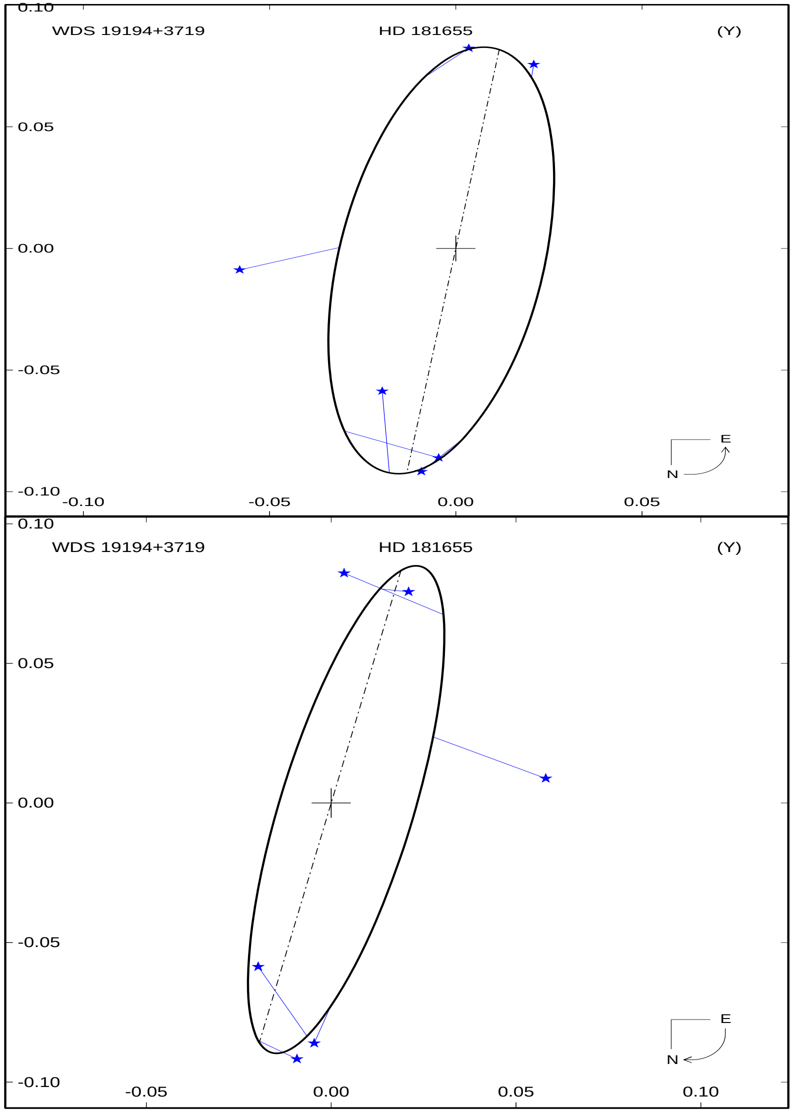




χ Draconis

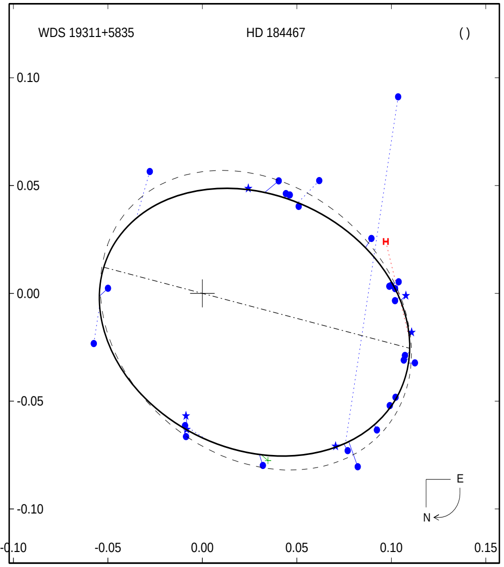
HD 181655

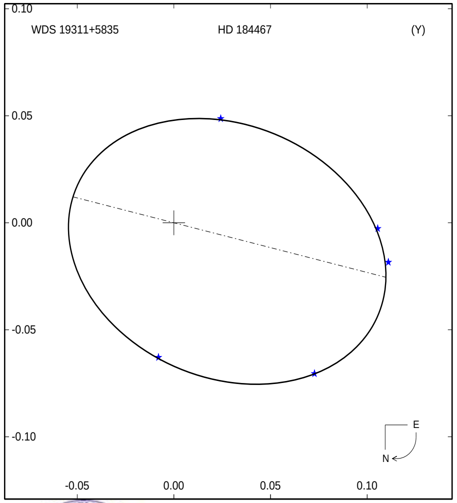
- Observed both by speckle (H. McAlister (1987)) and radial velocity surveys (D&M (1991), Nidever et al (1979), Nordstrom et al (2004)
- Low radial velocity amplitudes (no variation over 100 m/s) and no speckle companion detections
- Presumed to be a singular G8 dwarf with large proper motion. (-62.2 -183.1 mas/year)
- First new detection to date for this effort
- Close system (d=25.3 pc) perfect target for CHARA and should have been discovered by speckle



HD 184467

• Previously used as an IAU velocity standard star (Oops!)
• Double-lined spectroscopic system with P=494 days with the orbit discovered by McClure in 1983 on the DAO 1.2m (Dbl lines only 20% of the orbit)
• Speckle Interferometry points from 1980 - 2000 were used along with the RV orbit for two separate combined solutions by Pourbaix (2000) and Arenou (2000) providing much the same result.
• Provides an excellent test to see if the location of the secondary is calculated by CHARA data to be where the orbit predicts it will be





HD 184467 – Orbital Elements

Elements	Pourbaix(2000)	Arenou(2000)	CHARA(2008)
P (days)	494.091± 0.26	494.75 ± 0.48	494.16 ± 0.58
T (JD)	46164.9 ± 1.7	48641.21 ± 3.1	46671.43 ± 8.5
a (mas)	86 ± 1.4	84 ± 3	84.2 ± 0.84
e	0.360 ± 0.0078	0.34 ± 0.013	0.371 ± 0.006
ω	356 ± 2.1	177.8 ± 2.1	16.6 ± 4.1
i	144 ± 2.4	144.6 ± 1.7	144.0 ± 1.29
Ω	243 ± 1.5	74.6 ± 6.8	256.9 ± 2.7
π_{orb} (mas)	59 ± 4.1	57.99 ± 0.57	59.16 ± 2.04
M_P	0.8 ± 0.15 $M_\odot$	0.83 ± 0.09 $M_\odot$	0.82 ± 0.09 $M_\odot$
M_S	0.8 ± 0.14 $M_\odot$	0.79 ± 0.09 $M_\odot$	0.77 ± 0.09 $M_\odot$

HD 184467 M/L Relation

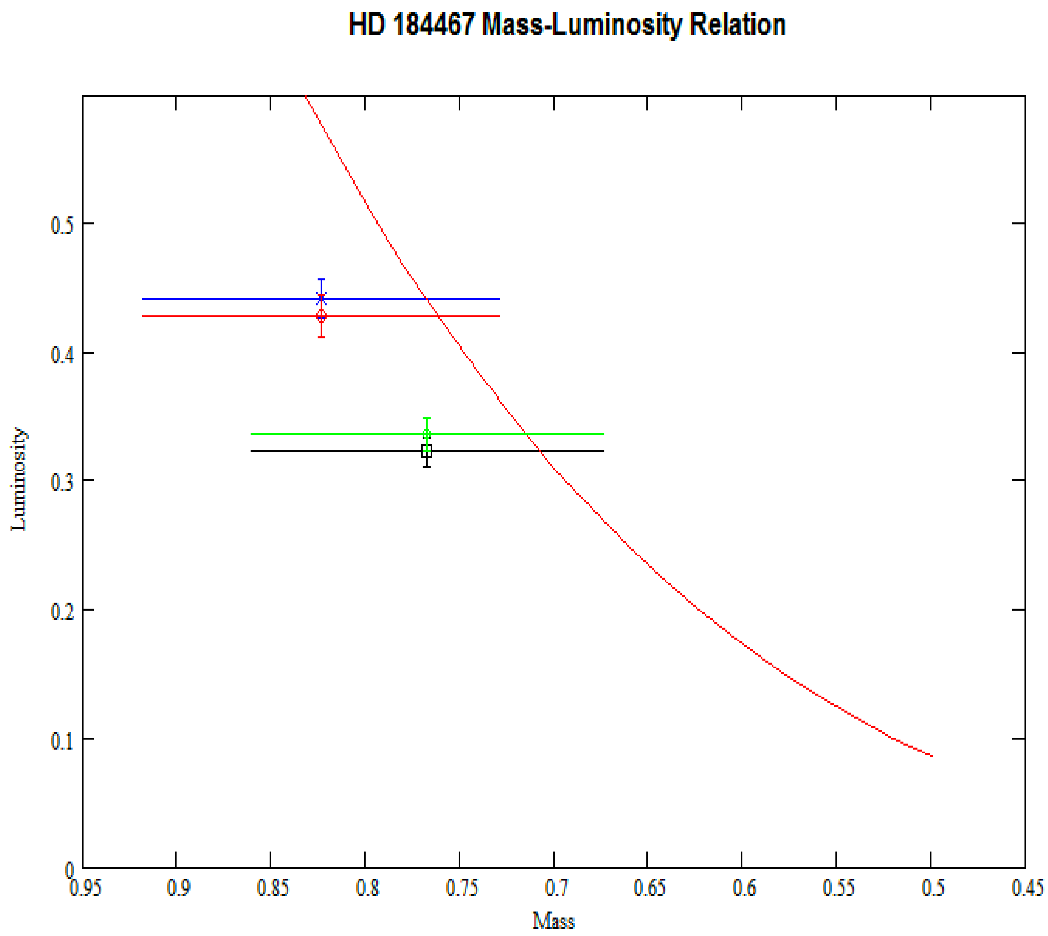
Luminosities

Primary:
0.442±0.015 L⊙
&
0.429±0.016 L⊙

Secondary:
0.323±0.011 L⊙
&
0.336±0.013 L⊙

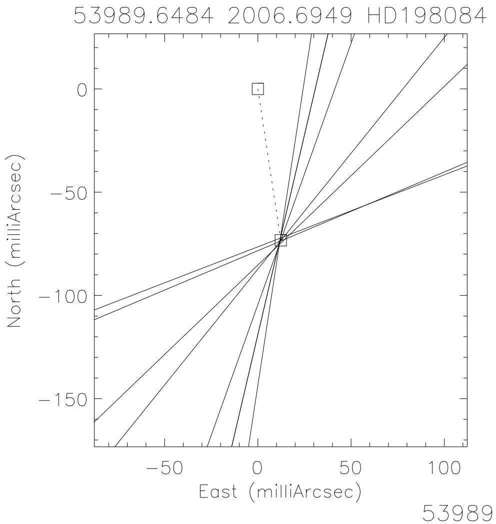
$\log(L/L_\odot) = 3.8 \log(M/M_\odot) + 0.08$

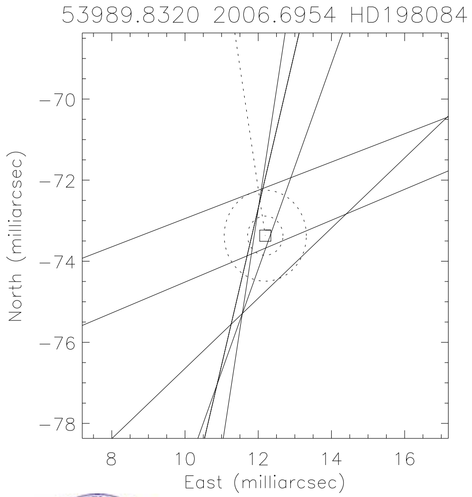
[Fe/H] = -0.22



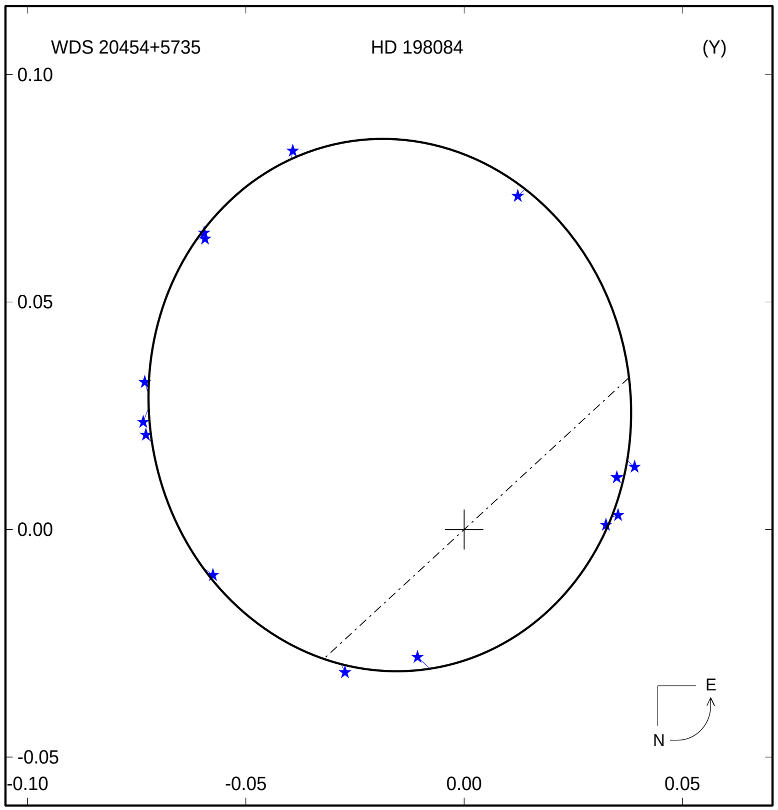
HD 198084 – CHARA data

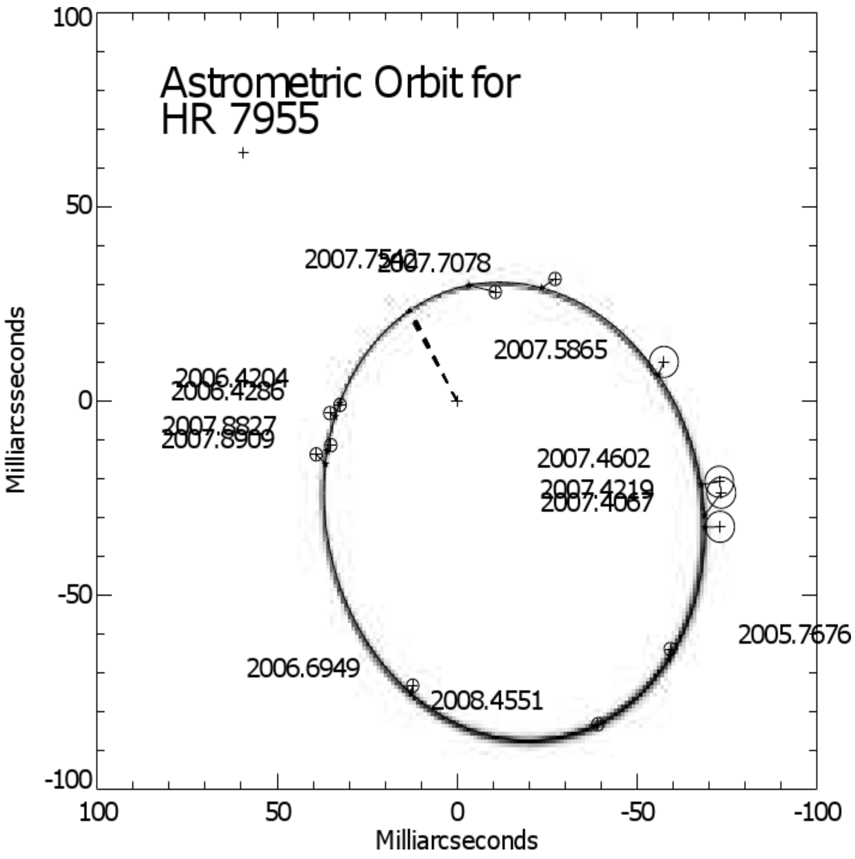
- Had been looked at by various RV projects dating back to 1898
- Abt & Levy (1976) and Beavers & Eitter (1986) failed to detect the RV variations among others.
- R.F Griffin (1999) did a comprehensive study of the system and determined a spectroscopic orbit for the pair of nearly equal “F8” stars.
- Bright system (m_V = 4.5, m_k=3.2) and with 40-100 mas angular separation, was a perfect target for speckle, yet no observations have before or since been done.
- Predicted inclination of 23 ± 1° would allow masses to fall within the correct range for spectral type





HD 198084 – Orbit





HD 198084 Orbital Elements

Elements	ORBGRID (Hartkopf)	Monte-Carlo (JDM)
P (days)	523.36 ± 1.25	523.87 ± 1.53
T (JD)	50205.84 ± 9.36	50205.2 ± 7.5
a (mas)	66.75 ± 1.09	64.5 ± 1.2
e	0.5527 ± 0.0068	0.5470 ± 0.0074
ω	81.7 ± 3.9	68.40 ± 3.02
i	29.49 ± 2.1	22.71 ± 0.11
Ω	311.3 ± 4.4	325.3 ± 5.6
π_{orb} (mas)	48.6 ± 3.3	35.45 ± 1.24
M_P	1.54 ± 0.16 $M_\odot$	1.37 ± 0.10 $M_\odot$
M_S	1.50 ± 0.16 $M_\odot$	1.28 ± 0.09 $M_\odot$

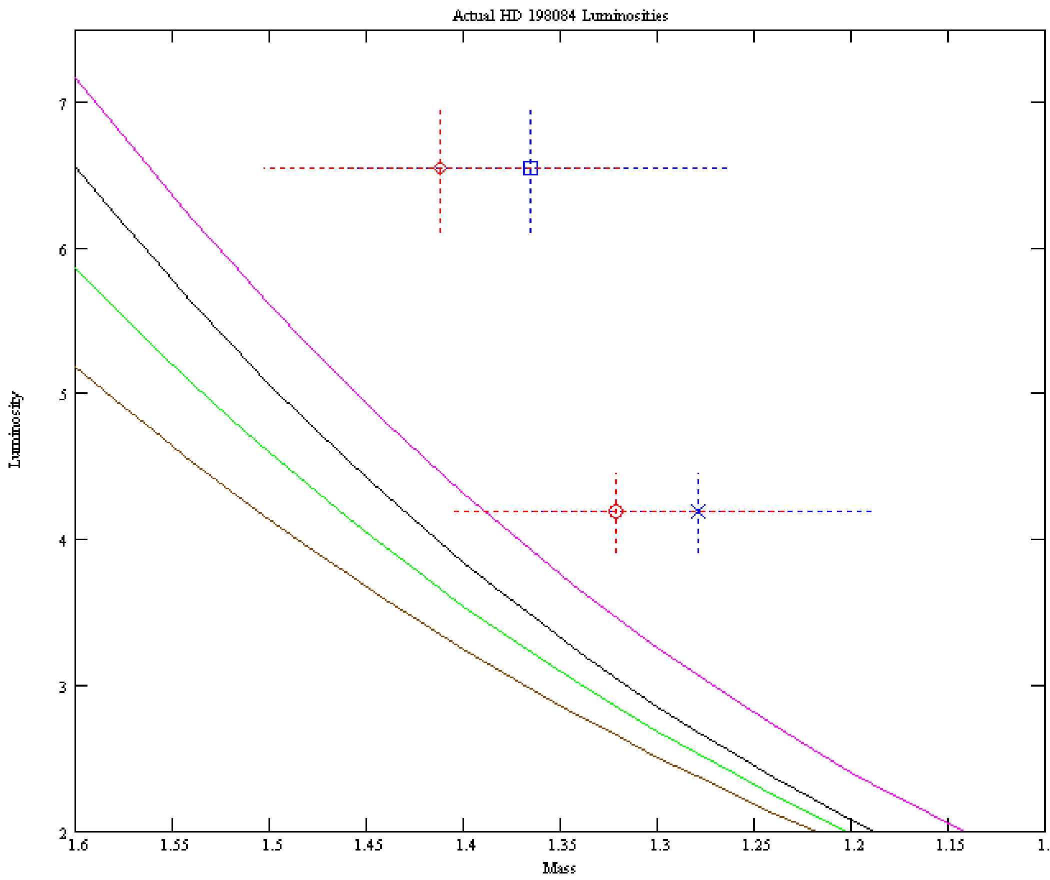
HD 198084 M/L Relation

Luminosities

Primary:
6.5±0.4 $L_\odot$
&
6.0±0.4 $L_\odot$

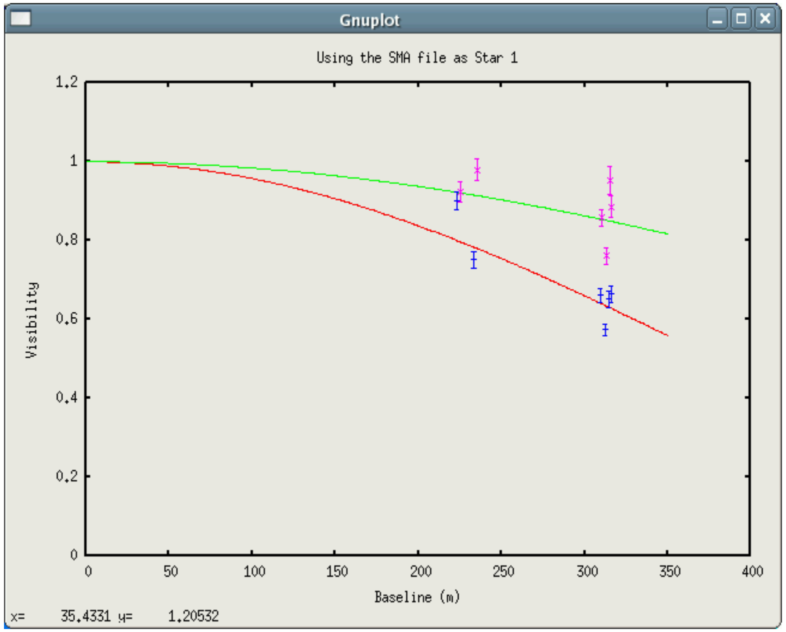
Secondary:
4.2±0.3 $L_\odot$
&
4.7±0.3 $L_\odot$

MS Luminosity Relation
$L \propto M^\alpha$ with α = 3.5, 3.75, 3.8, and 4.0



Utilizing Calibration

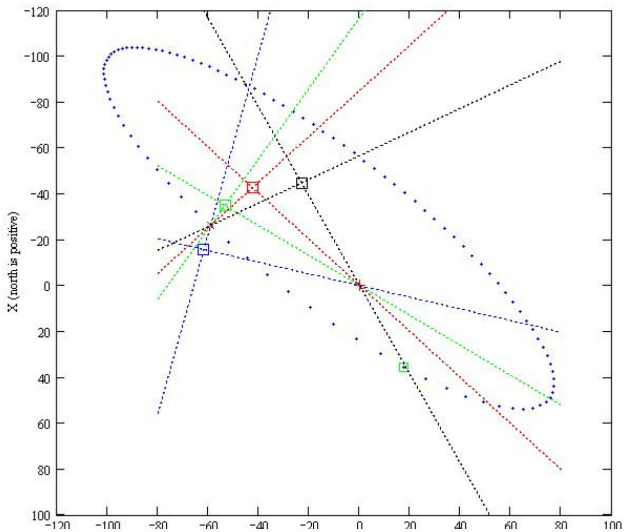
- Adding calibrators to obtain magnitude difference and radii
  - With SFP, it is unnecessary to remain on one object for a long period.
  - Requires two baselines and several data points per baseline
  - Allows simultaneous solving for magnitude difference and radii
  - Testing on HD 198084 from October 2008 gives: (in K)
    - Beam Ratio = 0.64
    - Magnitude Difference = 0.485
    - m_k = 3.80 (p) and 4.29 (s)
    - Linear Diameters = 2.6 and 1.6 R_{sun}
- Further exploration of this in the 2009 season.



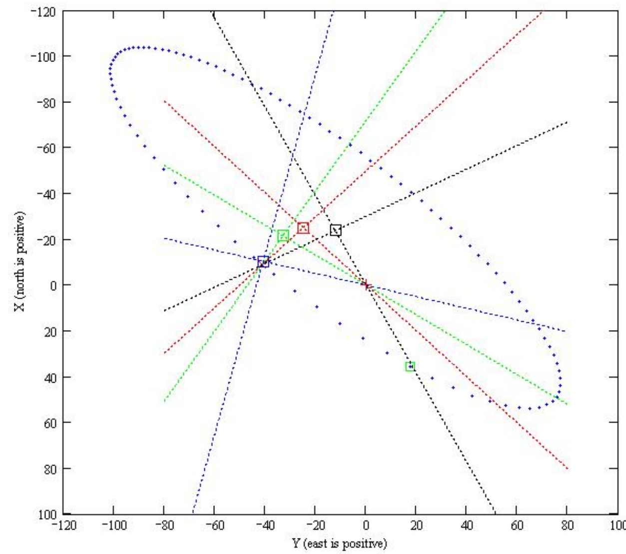
Current and Future Plans

- Two upcoming runs in 2009
  - Collecting SFP and Calibrated SFP data in conjunction with B. Mason and T.A. ten Brummelaar
    - Chi Draconis, HD 184467, and HD 198084
- Additional subgiant observing with Classic and VEGA
  - Obtaining orbits of other binary A, F, and G subgiants with possible SFP
  - Radii and spectroscopy of these and other single subgiants with VEGA

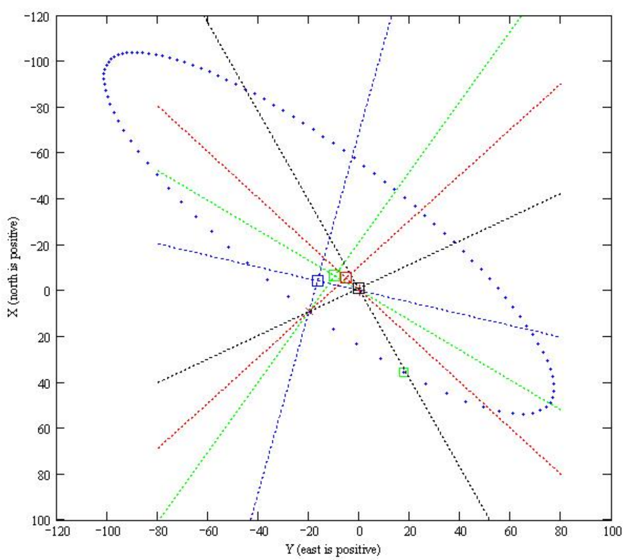
HD 170153

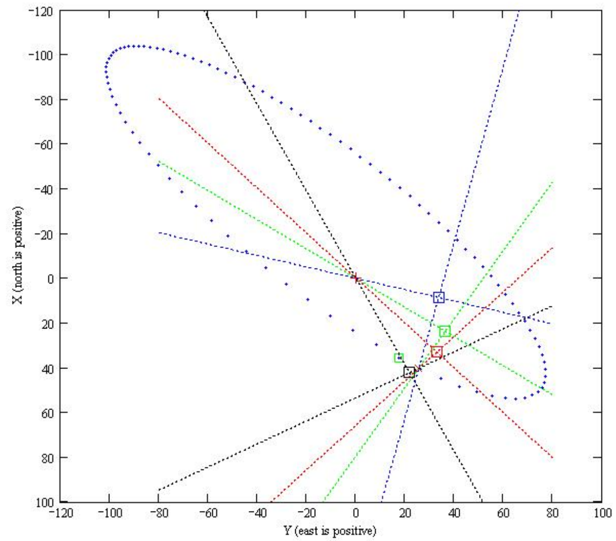


HD 170153



HD 170153





Discussion

- With proper planning, SFP data collection can be quite efficient
- High quality orbits can be obtained from SFP data
- Inclusion of calibrators with SFP orbital analysis can obtain radii in addition to orbits and the full characterization of the systems properties
- Outside sources of V and K magnitudes, spectroscopic orbits, and V magnitude difference are needed
- Detection of previously unknown companions is possible
- Successfully overlaps the gap between visibility and speckle visual orbits and allows astrometric observations of many previously unreachable spectroscopic binaries