Separated Fringe Packets

Results and Prospects

Astrometric Bootstrapping

- When a higher resolution capability is applied to double stars, pairs which were previously at the limit can be routinely observed.
- Historically, this was through telescope aperture but also can be applied to a method of collection.
- In the 19th Century successive Clark refractors, at the time the largest telescopes in the world, were able to resolve closer, known white dwarf companions of Sirius and Procyon.
Speckle Interferometry

- Through both telescope aperture (access to 4-5m telescopes) and the technique to take advantage of it, speckle interferometry accomplished this from the 1970s.
- Clouds of micrometry measures became the “string of pearls” associated with speckle data, most obviously seen in the 28 orbits paper (Hrt1989).
- Separated Fringe Packet (SFP) work is optimized to take these pairs at the limit of speckle capabilities and make a similar gain.
Generic Figure Description

- Scale is arcseconds
- Lower right gives directions and motion
- The solid curve is the new orbit calculation. If a dashed curve is present it is the current “best” orbit.
- Filled blue circles are speckle interferometry points
- Stars are CHARA Array data
- Each point connected to the predicted orbit position by an “O-C” line
- Solid disk centered on origin is the V band resolution limit of a 4m telescope (30 mas)
- Broken line is the line of intersection of the plane of the orbit with the plane of the sky
**χ Draconis**

- CHARA Array data from $0^\circ$ is from June & September 2006 and August & October 2007.
- Three dashed lines from origin indicate predicted position on May 4, 11, and 18, 2009.
- Another scheduled observation June 1 just after periastron (not plotted).
\(\chi\) Draconis

- The orbit (Pbx2000b) is quite good:
\[
M_a = 1.03(0.05) \, M_\odot \\
M_b = 0.73(0.024) \, M_\odot \\
\pi = 122(2.1) \, \text{mas}
\]

- At that time, \(\chi\) Dra had completed 35 revolutions since the first resolution (Lab1974). As of the last Array resolution it is now 45 revolutions.

- The shortcoming of the relative astrometric orbit was the lack of coverage near periastron, predicted for May 31 this year.

- The next orbit will have 33% more orbits, 20% more data, and cover periastron.
SFP3: HD 129132


- The fuscia wedge is where the secondary is predicted to be from May 4 to May 18.
SFP3: HD 129132

- A spectroscopic triple, the orbit (Scf1991) is good and includes solutions for both the closer (P = 101.6d) as well as this pair.

- This system may be appropriate for an analysis like that for CHARA 96 where the wider pair serves as a calibrator for a baseline solution of the inner pair.

- Considering the wider pair only, at the time of the dashed orbit shown here, HR 5472 had completed ~1.3 revolutions since the first resolution (McA1979b). As of the last Array resolution it is now ~3.4 revolutions.

- Coverage due north now adequate. The object will be due south from late 2012 to early 2013.

- Orbit is obvious need of correction.
SFP3: HD 157482

- CHARA Array data from 180° is from May, June & July 2007 and May, July & August 2008.

- The fuscia wedge is where the secondary is predicted to be from May 4 to May 18.
Like HR 5472, this pair is also a spectroscopic triple with a good recent orbit (Mut2008) which may be appropriate for a combined approach.

Array data at crucial phases not previously observed can make improvements on the dashed orbit shown here.

The larger than typical O-C for some Array data is due to inadequate rotation with one baseline used, or difficulties extracting separated fringe packet data at projected separations which were quite close.
SFP2: HD 178911

- CHARA Array data from $0^0$ is from June, July & October 2007 and May & August 2008.

- The dashed line is the predicted position May 18, and the fuscia wedge is 10-12 August.
• While the combined solution orbit (Tok2000) appears superficially adequate the errors are large due to the paucity of resolved data at the time (N=6):
  \[ M_a = 1.07 \pm 0.37 \, M_\odot \]
  \[ M_b = 0.84 \pm 0.29 \, M_\odot \]

• Now, with over three times the data the errors, and masses, are getting much smaller:
  \[ M_a = 0.724 \pm 0.045 \, M_\odot \]
  \[ M_b = 0.562 \pm 0.043 \, M_\odot \]

• The pair was last at closest approach during the 2007 winter shutdown. It will next be there in mid 2011.
SFP3: $\mu$ Ari

- CHARA Array data is from October 2007.

- The dashed wedge is where the pair is predicted to be from October to December 2009.
SFP3: $\mu$ Ari

- Although older, the relative orbit (Msn1997a) adequately covers the data. At that time, the pair had completed ~1.5 revolutions.
- With the Array point, the pair has gone through over 3.6 revolutions, which much more significantly constrains the orbital period.
- The sole Array point was at a crucial separation, which places constraints on the inclination.
Possible Future Target: δ Sco

- Filled stars here represent data taken with the USNO speckle camera.

- The four wedges represent predicted positions from April to June 2009-12.
Possible Future Target: δ Sco

- Due to the very high (0.94) eccentricity and the lack of data points to constrain it near periastron, the orbit (Msn2009) was calculated by fixing eccentricity.
- Exhibiting Be star characteristics near periastron, SFP measures over this time will constrain the orbit while possibly provide other opportunities to examine the Be disk (Sch2009, Tou2009).

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Other Possible Targets

$V < 7$
$\delta > -20$
$N > \sim 10$
$G > 1$

$10 \, \text{mas} < a_{\text{periastron}} < 30 \, \text{mas}$

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Properties of “Other” Targets

- Of these, some may be inappropriate due to large $\Delta m$ in K band, e.g., HR 233, $\delta$ Sge.
- These typically fall into two broad categories:
  - Long period, high e systems with a small observation window, and
    - $\gamma^2$ And at top left, $P \sim 64$ y, $T_0 \sim 2016$
  - Shorter period, lower e systems that happen to spend large fractions of their orbit closer than 30 mas.
    - 79 Her at bottom left, $P \sim 10$ y, $T_0 \sim 2014$
References

- Msn1997a = Mason 1997 AJ 114, 808
- Mut2008 = Muterspaugh et al. 2008 AJ 135, 766
- Scf1991 = Barlow & Scarfe 1991 AJ 102, 2098
- Sch2009 = Schaefer et al. 2009 AAS #213, #409.09
- Tok2000 = Tokovinin et al. 2000 SvAL 26, 116
- Tou2009 = Touhami et al. 2009 AAS #213, #409.18