PHASES

The Palomar High-precision Astrometric Search for Exoplanet Systems

A Search for Planets in Binary Star Systems

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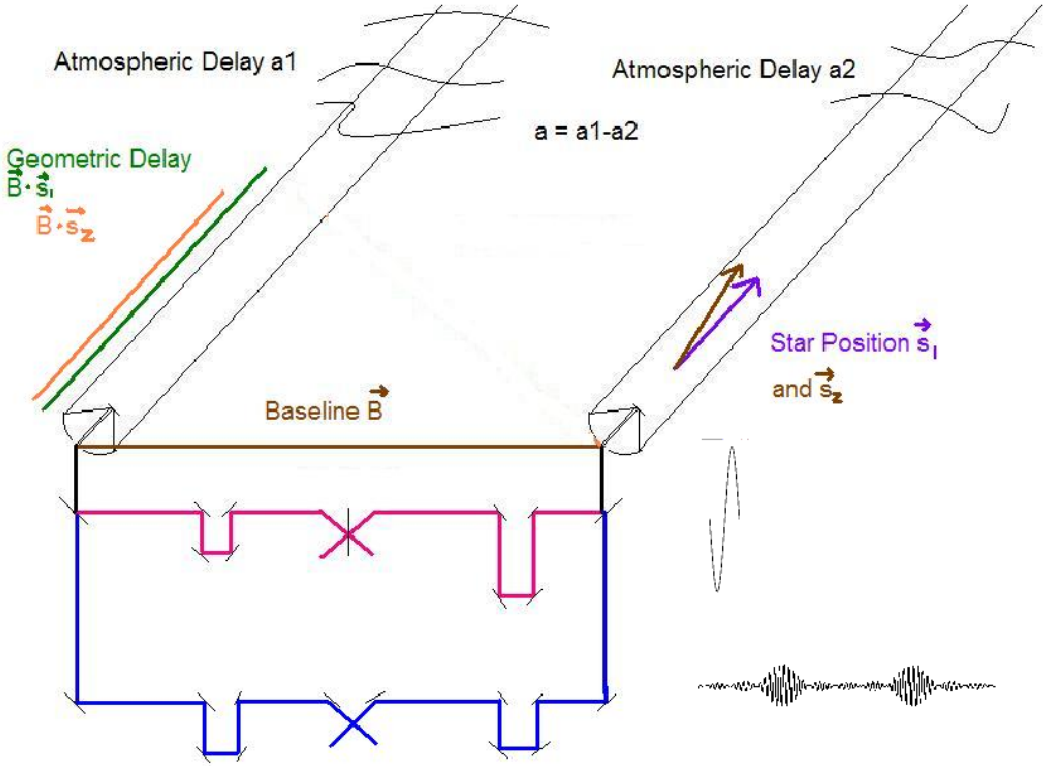
http://stuff.mit.edu/~matthew1/thesis/thesis.html

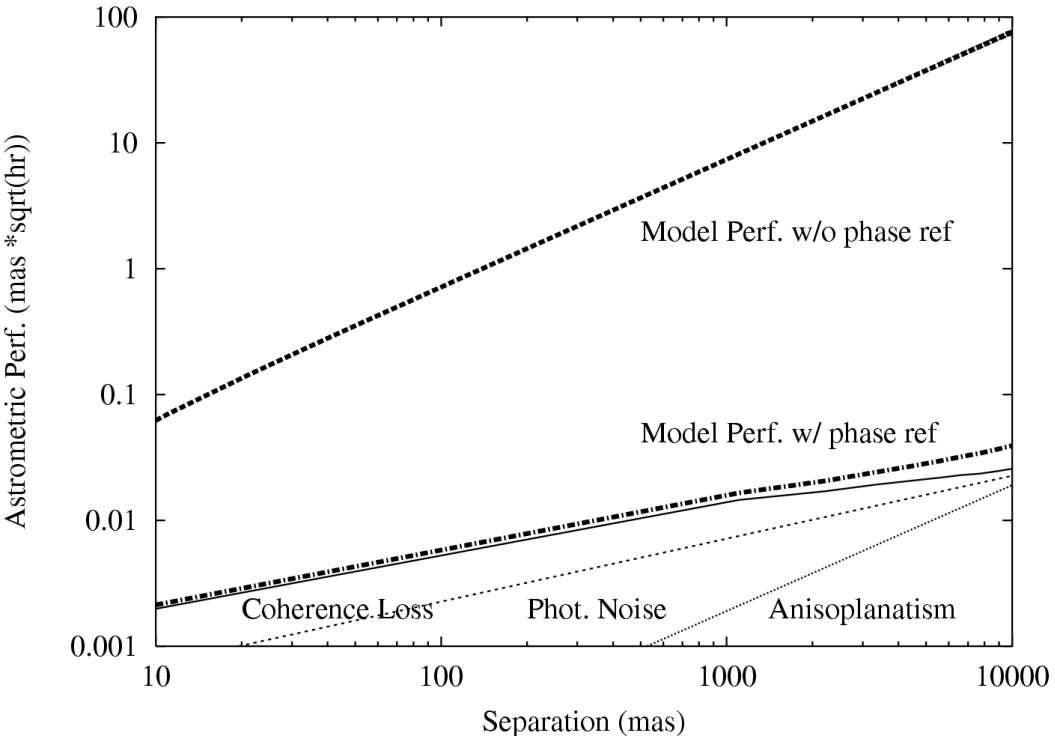
Phase-Referencing



- Fast tracking (10ms) determines a(t).
- Second detector stabilized, slowly scans the two stars.

Differential Astrometry: Theoretical Precision

$$\delta D = \delta\vec{s} \cdot \vec{B} - \delta d - \delta a$$

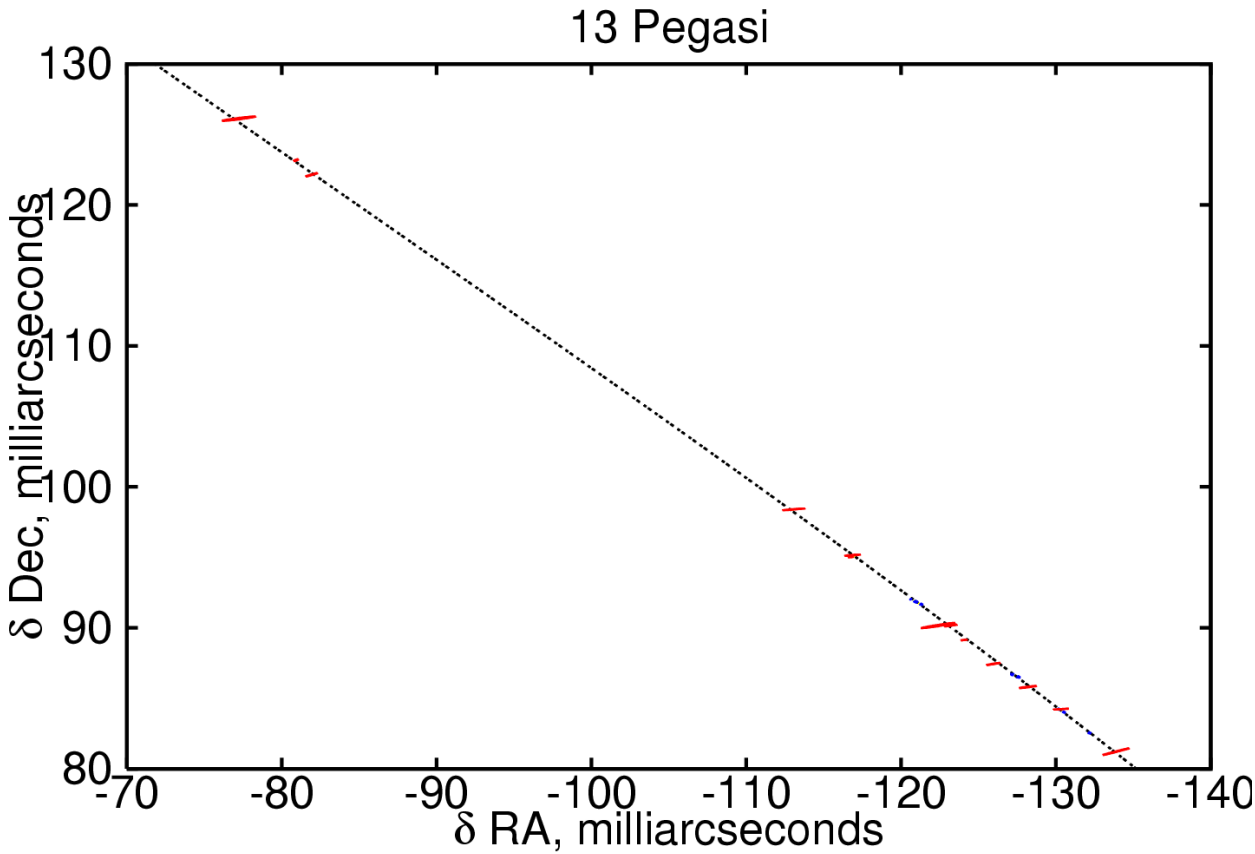


- Baseline $\vec{B}$ measured by wide-angle astrometry.
- Internal delay d measured by laser interferometer.
- $\delta a(t, \vec{s})$ nonzero due to two terms:
  1. Anisoplanatism: $\delta\vec{s} > 30$ arcsec.
  2. Coherence Loss: Temporal turbulence variations.

13 Pegasi

F2IV
33 pc, P=29y

- Median minor axis error: 16.4 μas
- Average relative precision: $\frac{16}{160000} = 10^{-4}$
- Slope consistent with speckle orbit.



δ Equulei

F7V+F7V

$P = 5.7058 \pm 0.0003$ years

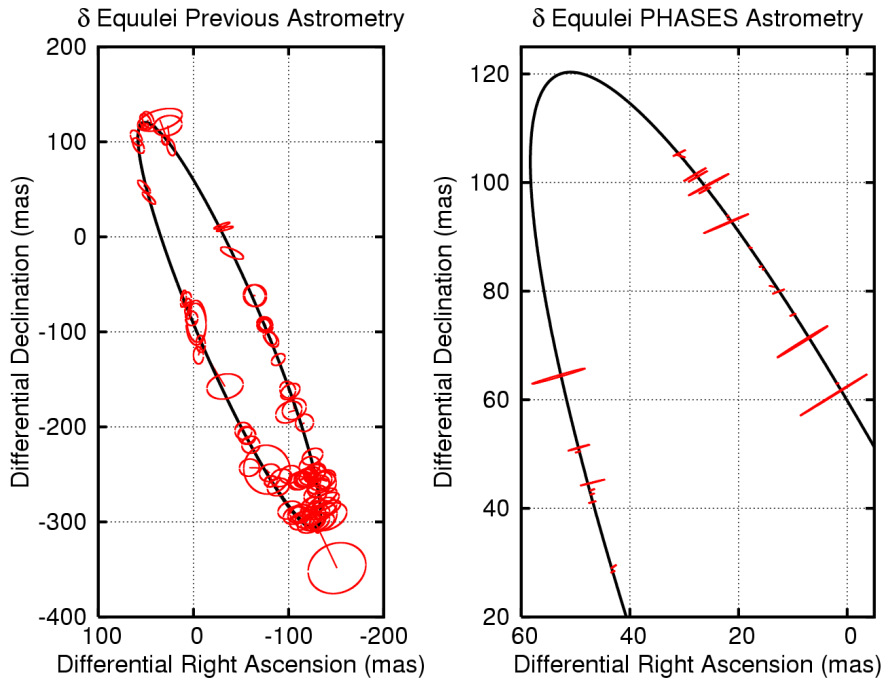
$d = 18.39 \pm 0.05$ parsecs

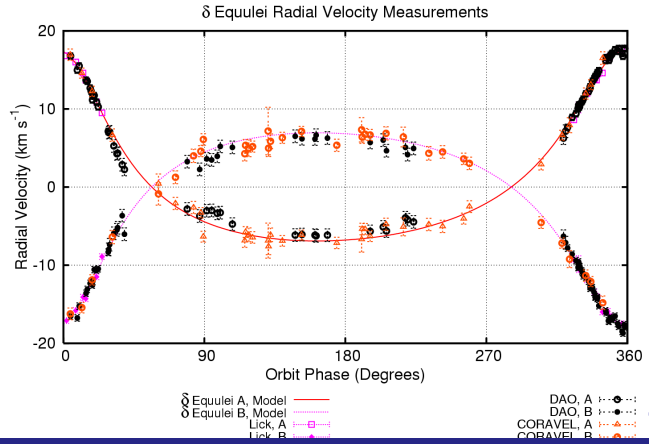
$V = 4.99,\ K = 3.27$

Each $1.19 \pm 0.01 M_\odot$

$M_p \geq 11.5 \left(\frac{P}{\text{month}}\right)^{-\frac{2}{3}}$ Jupiter Masses

astro-ph/0507585





κ Pegasi

A: F5 IV, 1.54 $M_\odot$

Ba: F5 IV, 1.67 $M_\odot$

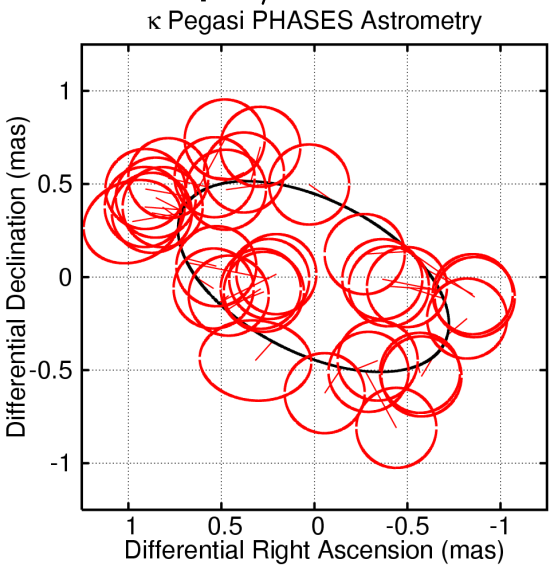
Bb: 0.82 $M_\odot$

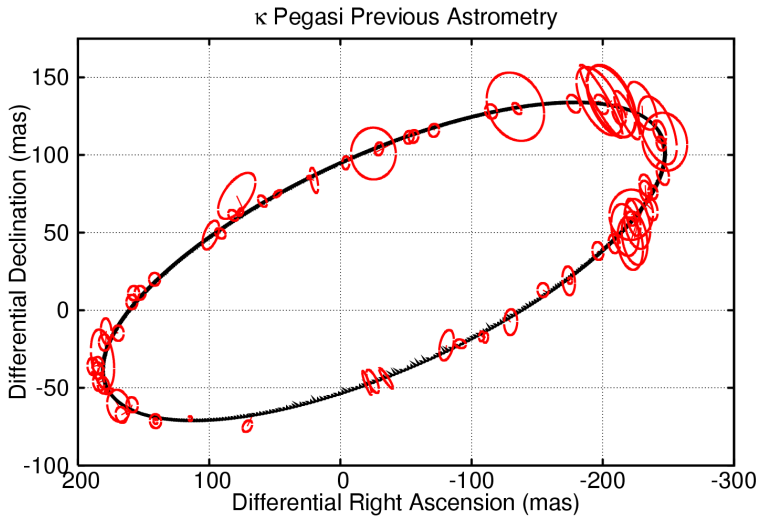
A-B Period: 11.6 years

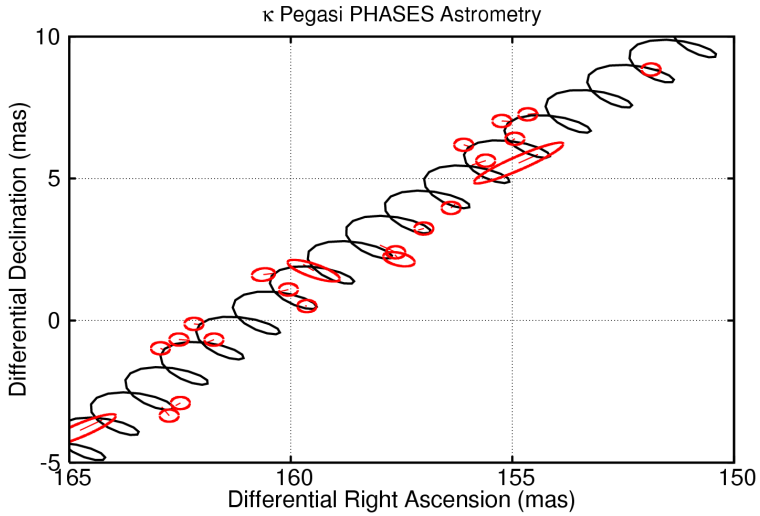
Ba-Bb Period: 5.97 days

Mutual Inclination: 43.8 degrees

astro-ph/0509406







V819 Herculis

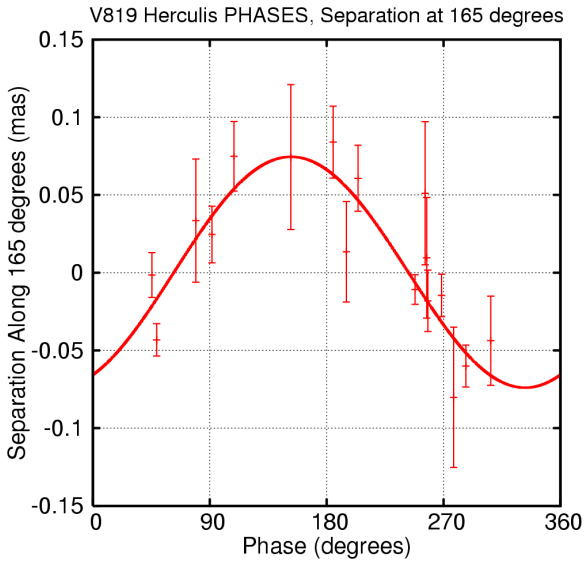
A-B Period: 5.5 years

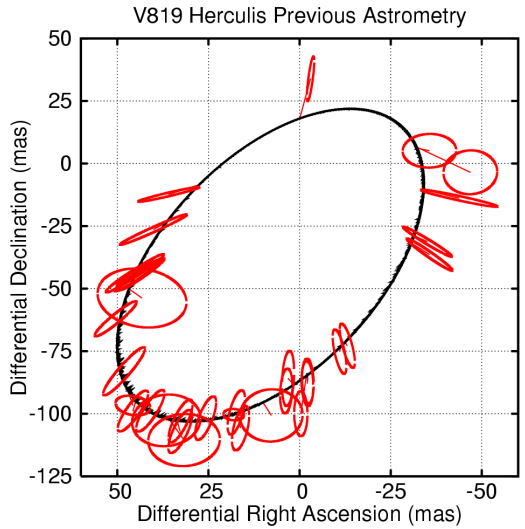
Ba-Bb Period: 2.23 days

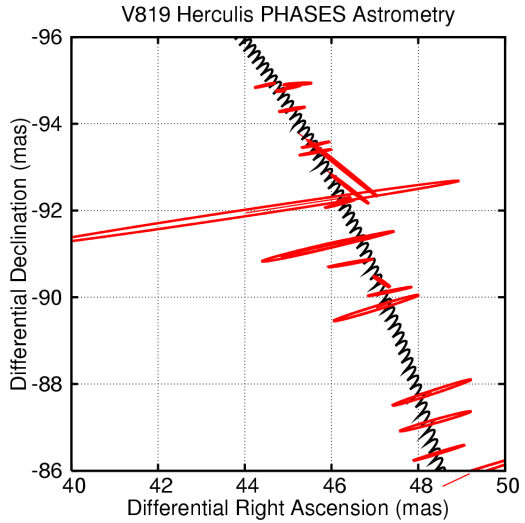
Ba-Bb shows eclipses

Mutual Inclination: 23.6 degrees

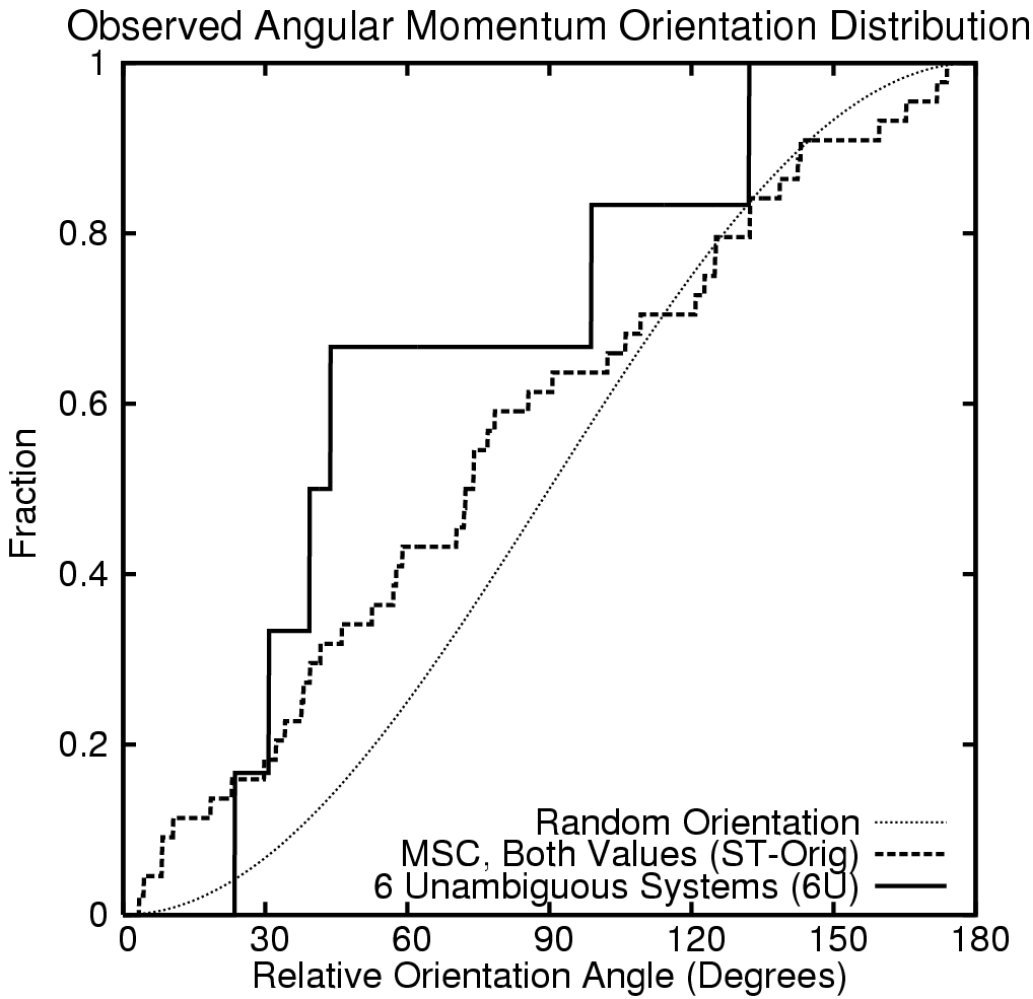
astro-ph/0509855







Mutual Inclinations

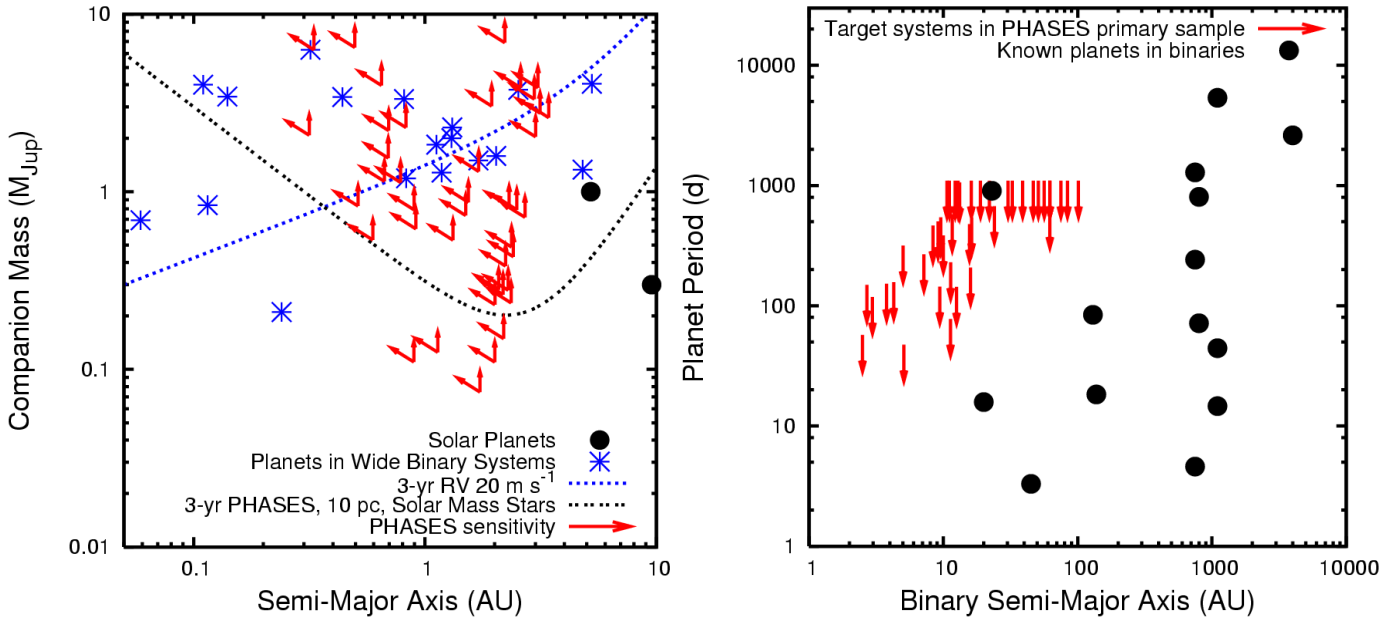


Future Work

$\approx$ 50 systems observable with *current* setup.

- Within view of PTI (dec $\approx +10$ to $+50$)
- $K < 4.5$
- Astrometry for $\Delta K < 1.5$. Direct detections at $\Delta K < 5$
- Separation less than 1 arcsecond
- Average $\mathrm{M_{pl,min}} = 0.7\mathrm{M_J}$.(3 $\sigma = 30\mu\mathrm{as}$)
- 36 systems: $\mathrm{M_{pl,min}} < 1\mathrm{M_J}$
- 17 systems: Maximum stable $\mathrm{P_{pl}} < 2\mathrm{y}$.

Conclusions



- Astrometry of sub-arcsecond binaries demonstrated at precisions $< 10^{-4}$.
- Astrometry detects faint companions to binary systems.
- A survey of sub-arcsecond binaries will search for planets around stars inaccessible to other methods.