Astrometric search for planets around white dwarfs in wide binary systems

Dijana Dominis Prester

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Microlensing → - short time observations
- terrestrial planets

Astrometry → - long lasting observations
- planetary orbits & masses

Why should we search for planets around white dwarfs?

- Stars like our **Sun** (G-type main-sequence stars) end up their lives as **white dwarfs**
- Understanding the **formation and evolution of planetary systems** around solar-type stars => understanding the formation and evolution of **life in Universe**

Why planets around white dwarfs?

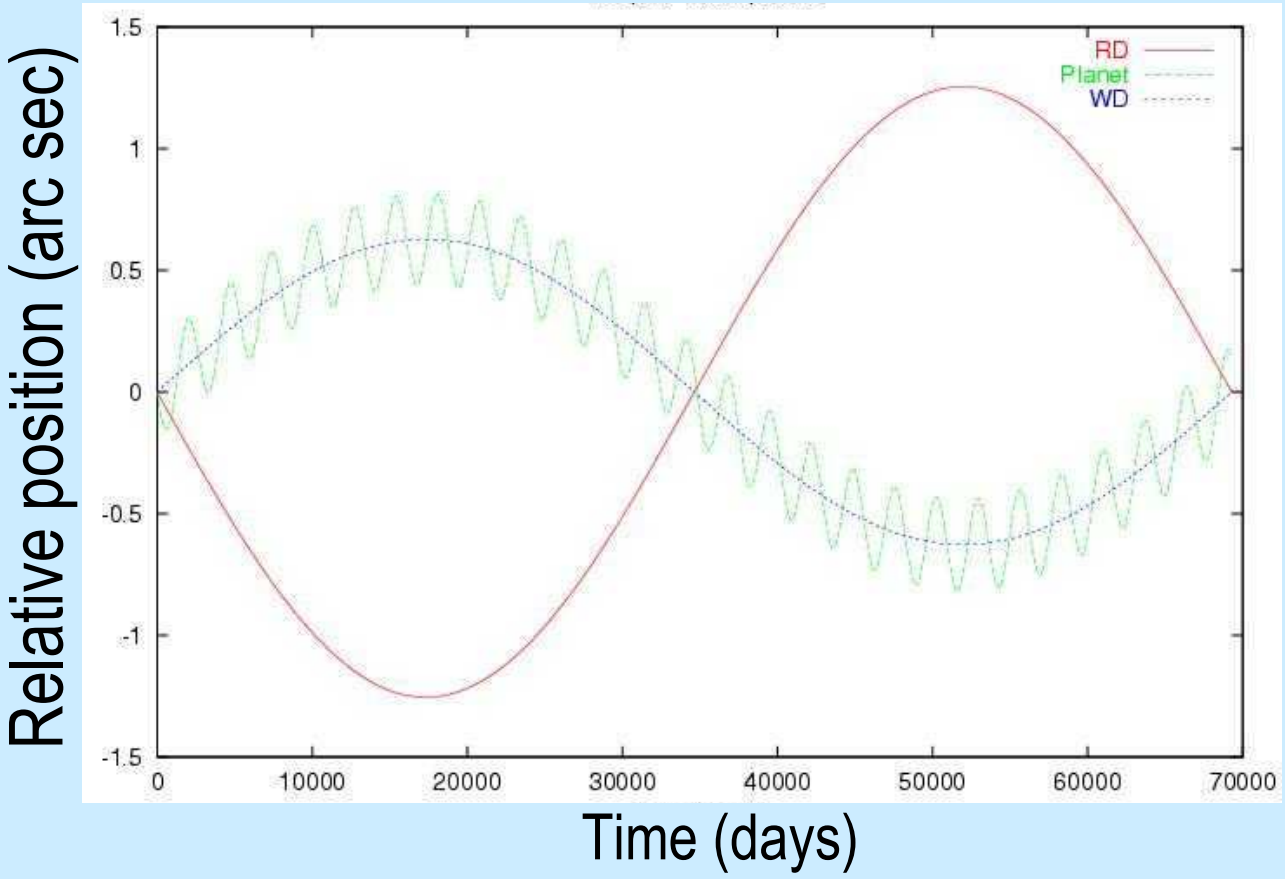
The mass loss => $\frac{a_{pl}(final)}{a_{pl}(initial)} = \frac{M_*(initial)}{M_*(final)}$

Planets in wide orbits (>5 A.U.) around white dwarfs should exist, but...

No planet around a white dwarf found so far!

Astrometric search for planets

Astrometric wobble: $A'' = \frac{m_P a_P}{m_* D}$



$[RD + (WD + Planet)]$

$P_P = 7\,years$

$a_P = 3\,A.U.$

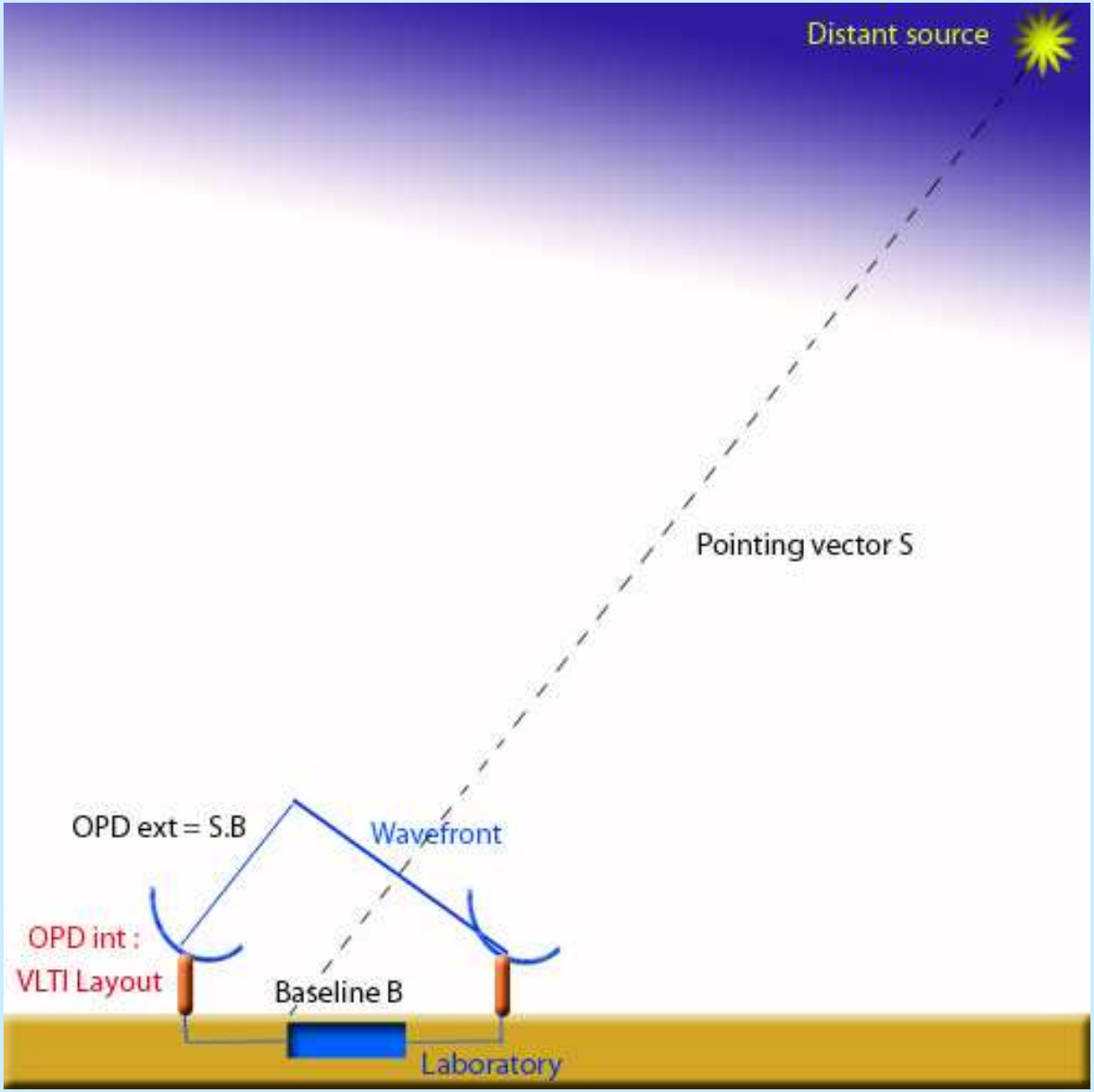
$m_{WD} = 0.5 M_{Sun}$

$m_P = 1 M_{Jupiter}$

$m_{RD} = 0.25 M_{Sun}$

$D = 10\,pc$

Interferometric Astrometry



PRIMA

(Phase Referenced Imaging and Micro Arcsecond Astrometry) facility on the VLTI

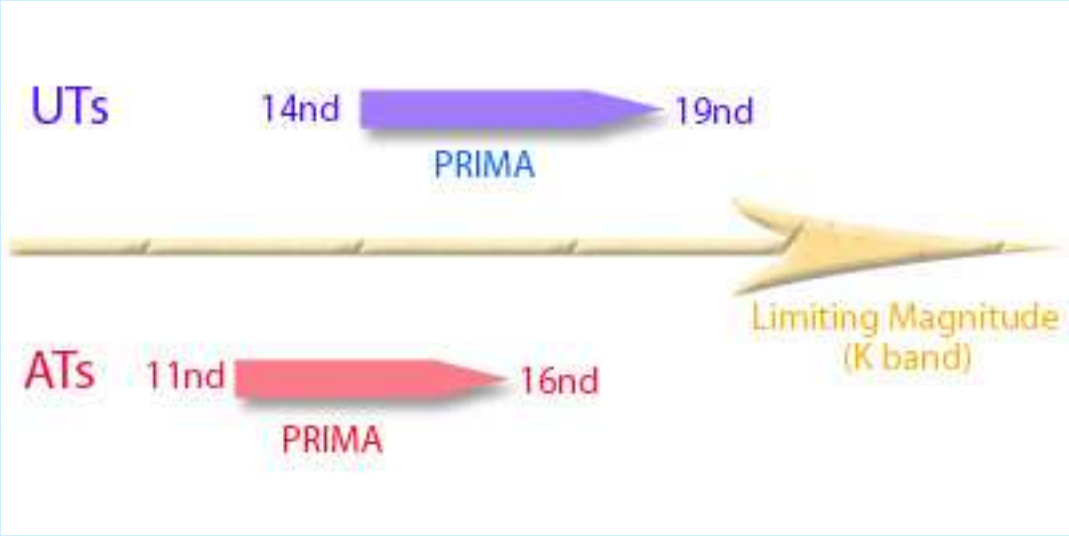
In operation 2008?

- **10 micro arc sec** astrometric accuraccy!
  (or at least 100 micro arc sec)
- need a bright phase reference star

2“ < d(target,ref.star) < 60“

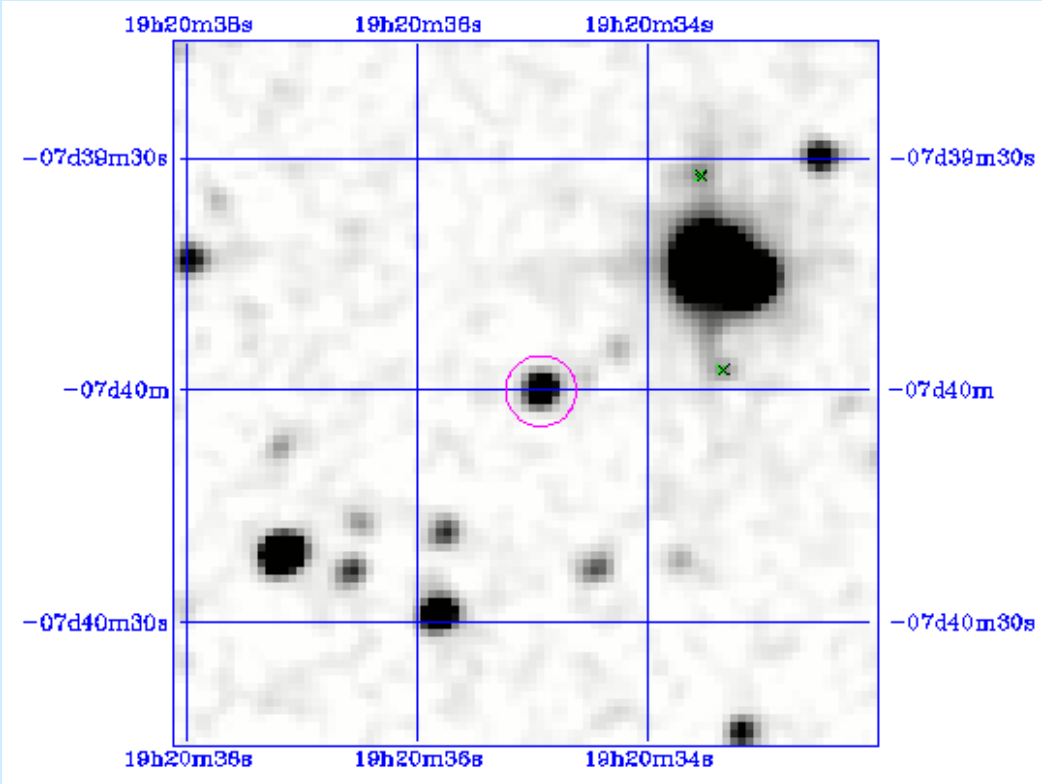
- a list of bright observing targets (WD-RD)
  (from Oswalt&Strunk 1994)

Limiting PRIMA magnitudes



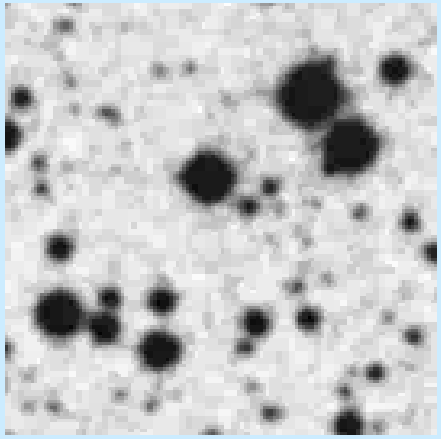
WD: L 923-21, *RD:* L923-22

(K=12.4) (K=7.4)



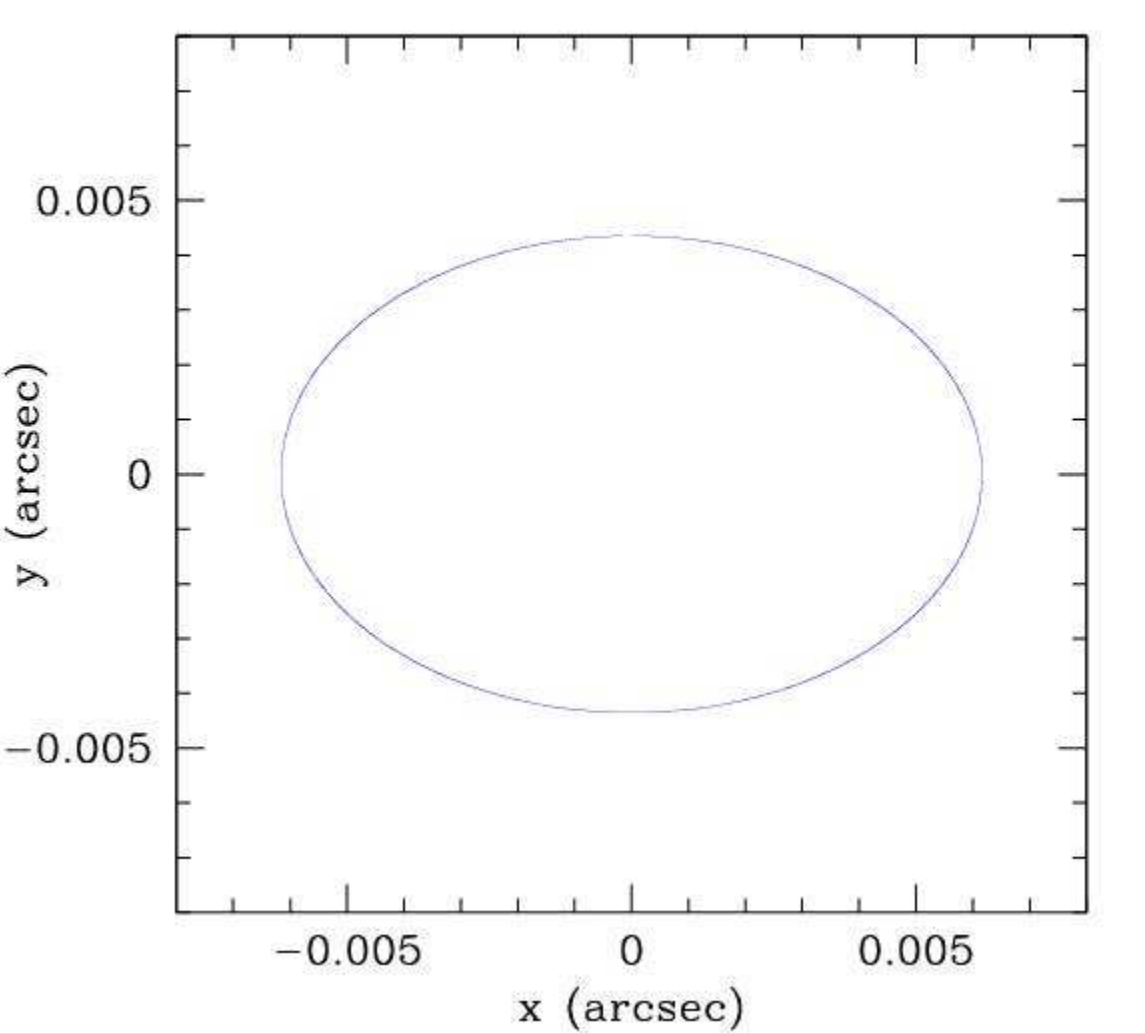
2MASS, 90“x90“
(2003)

d=27“
D=10pc



SuperCOSMOS SS
(1988)

A theoretical orbit



$$m_{WD} = 0.5 m_{Sun}$$

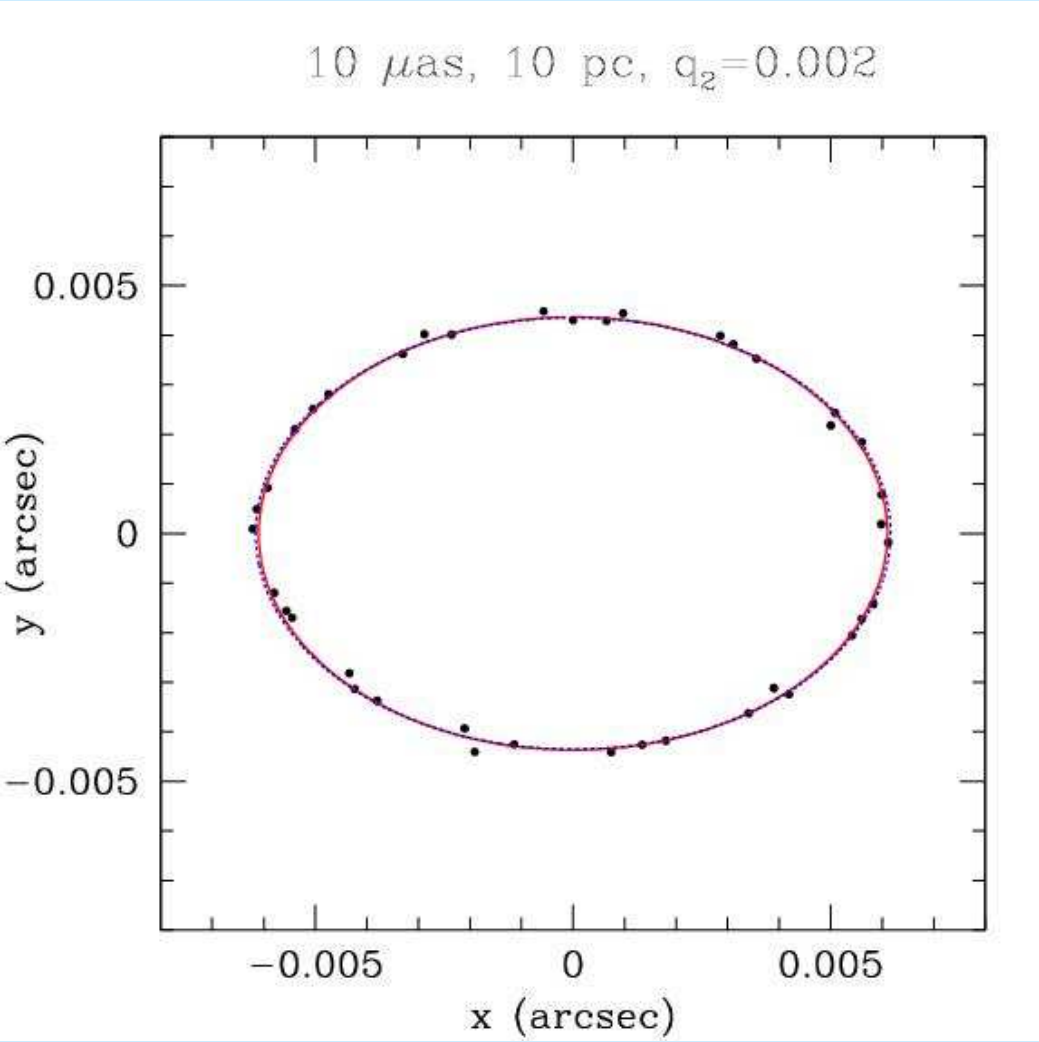
$$m_P = 1 m_{Jupiter}$$

$$d = 5\,A.U.$$

$$D = 10\,pc$$

$$P = 13\,years$$

$$i = 45^o$$



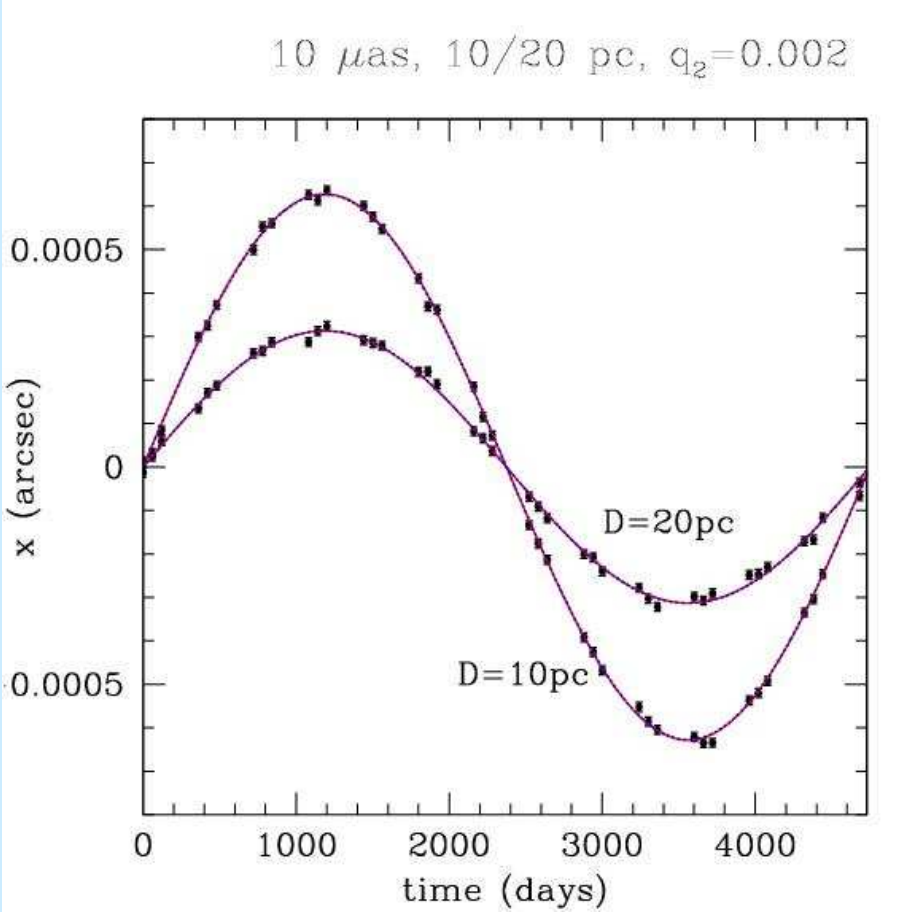
Simulated orbit

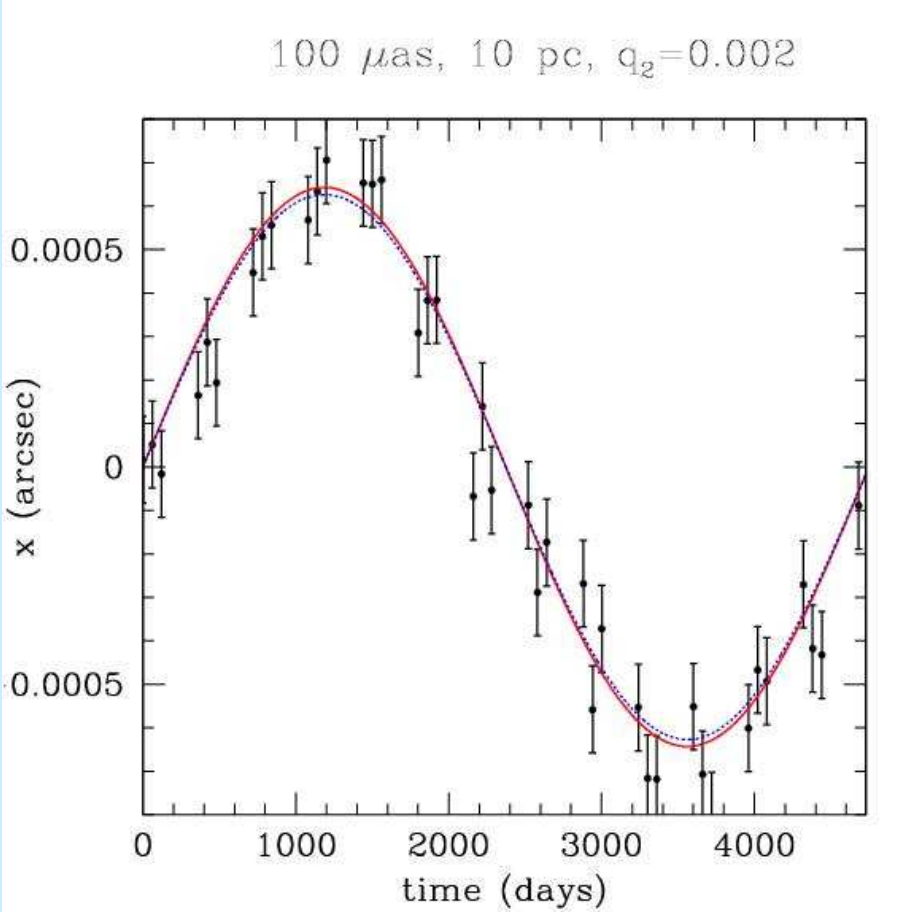
-Gaussian noise

- 1 data point every 2 months

- 6 month gaps (Southern targets)

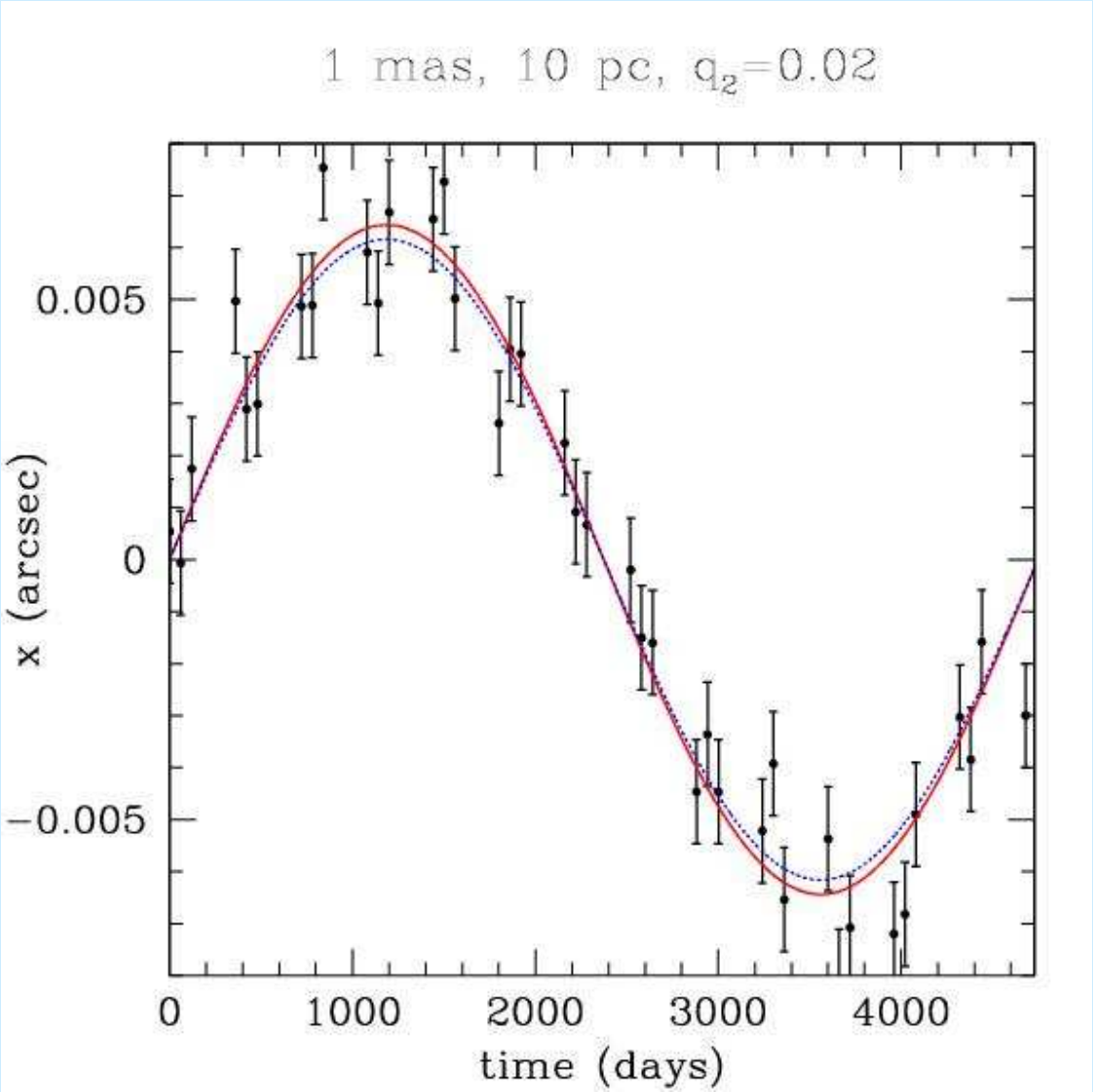
Simulated astrometric observations





dotted blue line: model
red line: best fit (Simplex)

Possible observations with existing facilities



Summary

- Planets around white dwarfs can be found with PRIMA when operating
- ~ 10 years of observations (3 data points per year) needed for masses and orbits

The differential phase

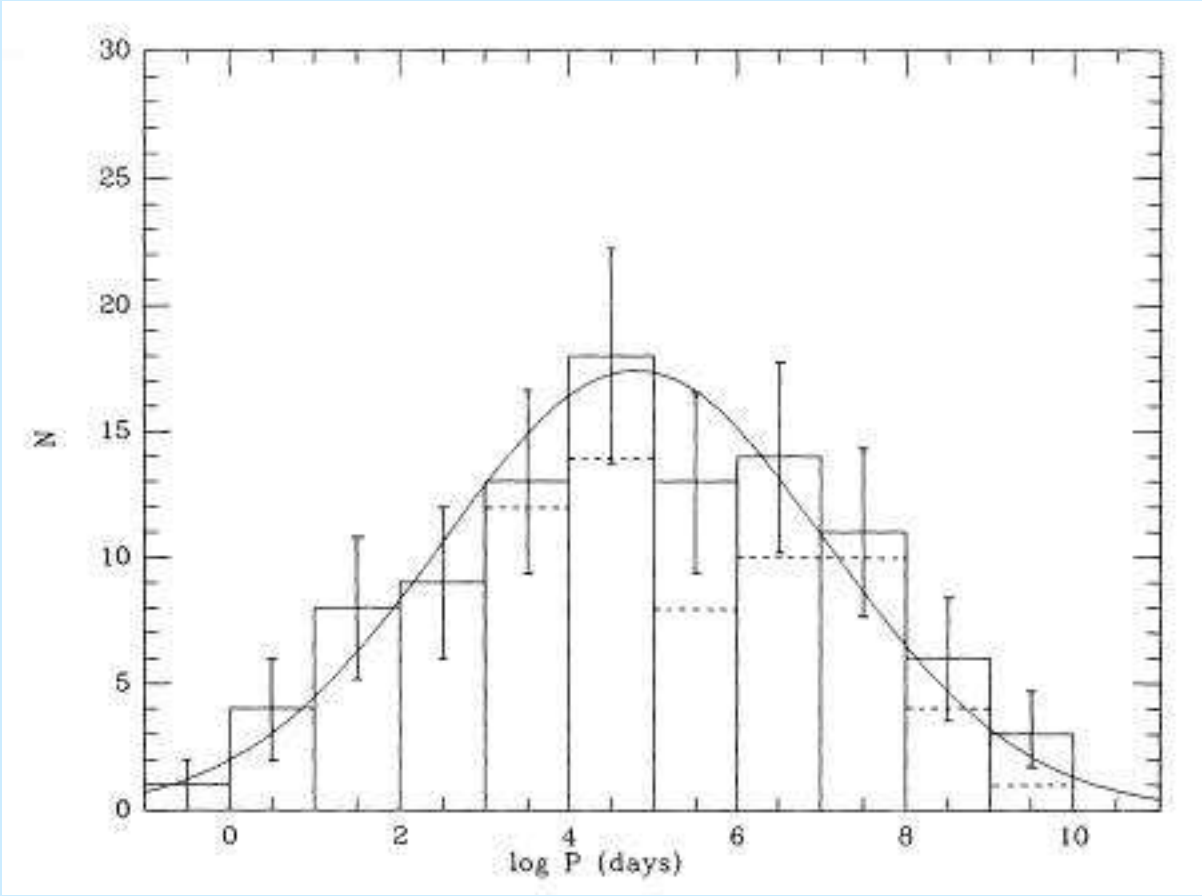
$$OPD_{R-star} - OPD_{Object} =$$

$$\Delta SB + \frac{\lambda}{2\pi}\phi_{Object} + OPD_{Atm} + OPD_{Int}$$

Periods of Binary Systems

- A large fraction of the Galactic stars are in binary systems
- Gaussian-like distribution in ***log P*** with **maximum** around 10^4 days
- (between 1 day and 10^{10} days)
- **Long period binaries** (P > 100 days): more binaries with **high mass ratios**

Distribution of binary periods



Duquenney & Mayor (1991)