Astrometric search in SDSS Stripe 82 for wide compact binaries

Claudia Conrad

Ralf-Dieter Scholz, Axel Schwope, Olivier Schnurr

AIP, Germany

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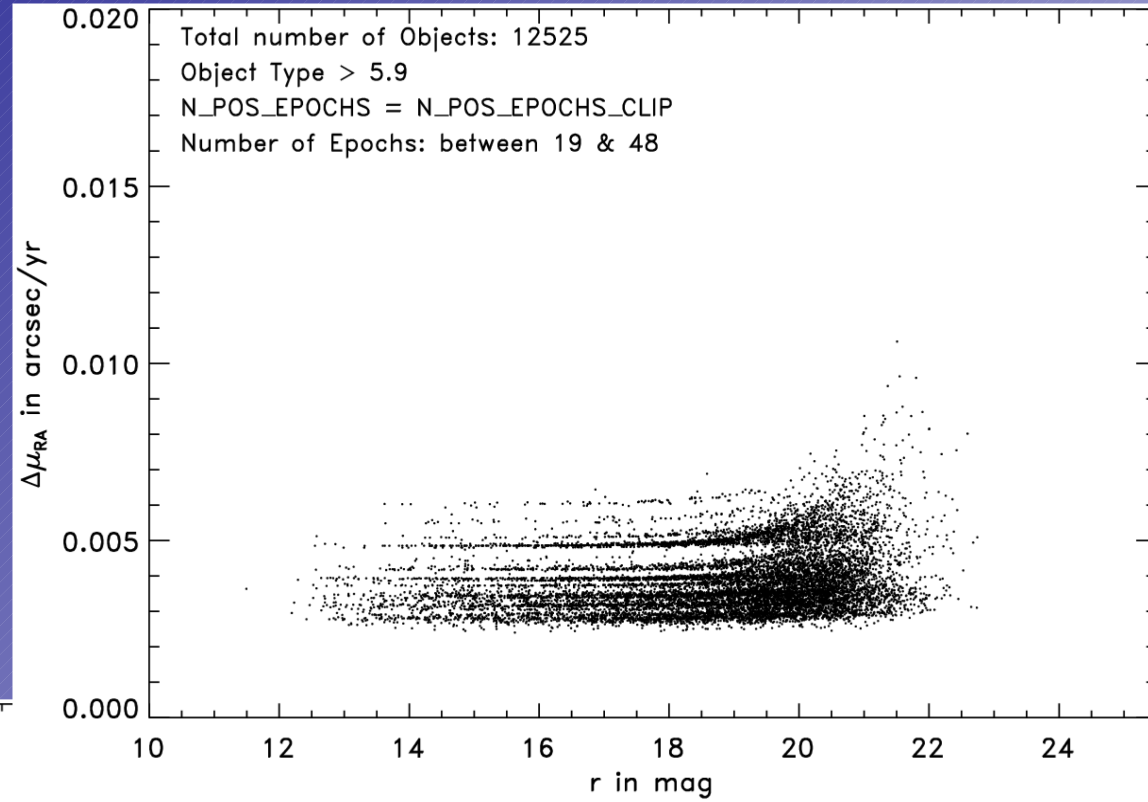
Wide Compact Binaries?

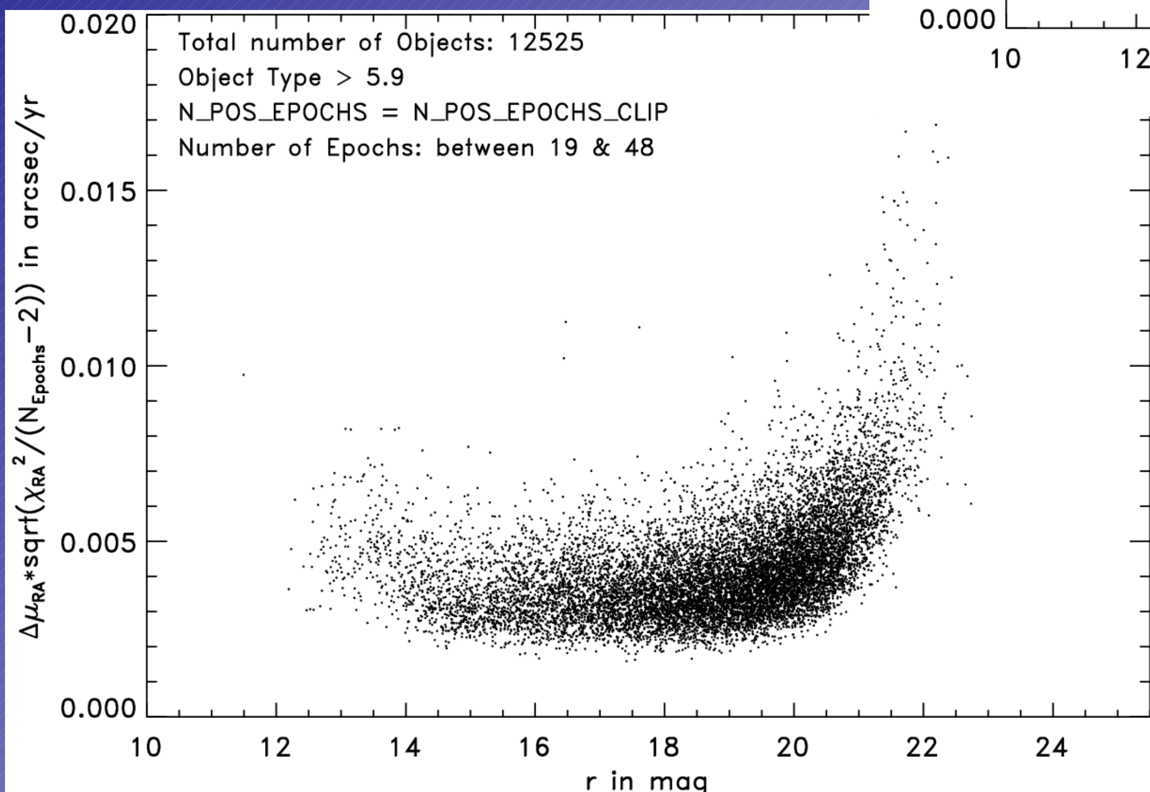
- Only close compact binaries known so far!
- Are there neutron star or black hole companions to M-dwarfs with orbital periods of several years?
- What could be the formation process for such systems?
  - Can the components evolve together, i.e. can the M-dwarf/the system survive the SN explosion of the massive component
  - Are such binaries a result of capture processes

Data set

- SDSS Stripe 82 catalogue by Bramich et al. 2008 → 1998-2005; area: ~250deg^2
- 20^h<RA<4^h, -1.25°<DEC<1.25
- 4 million stars and galaxies, repeatedly measured
- Providing photometric & astrometric measurements
- Mean positional uncertainty for stars: 35 mas
- For some objects spectra are available from the SDSS online database

Proper motions uncertainties provided by Bramich et al. (2008) catalogue are model errors → systematic features

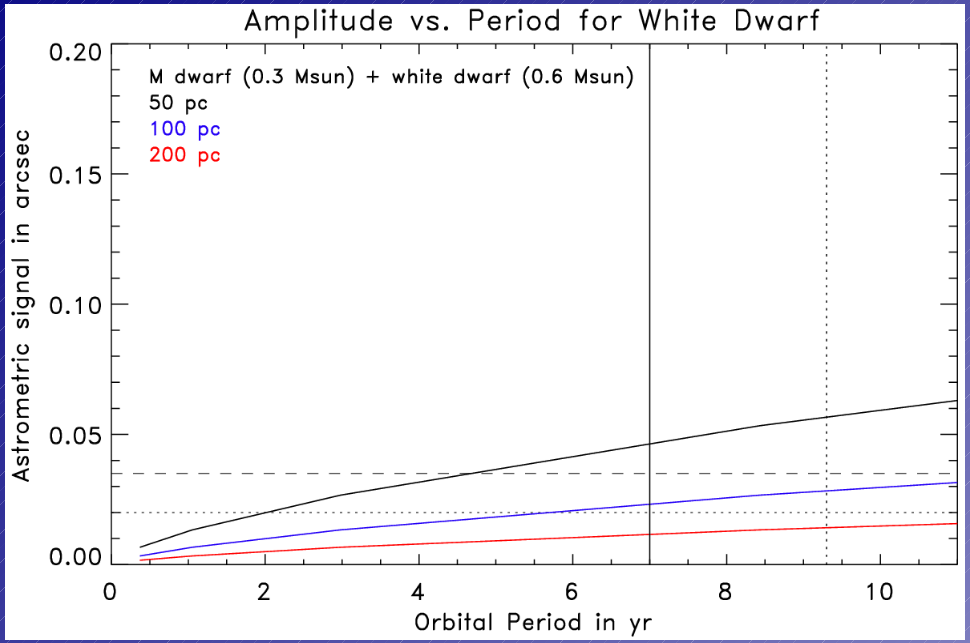




Obtain real proper motion uncertainties → normalise with listed χ^2 values

General selection criteria

- For saturated or too faint objects proper motion uncertainty systematically larger → magnitude cut
- First sample only contains well measured stars, i.e. objects not showing outliers in motion curve
- Aim to find neutron stars or black holes to low-mass stars → light dominated by low-mass component → only consider apparently isolated stars
- Astrometric signal should exceed the positional uncertainties → nearby objects



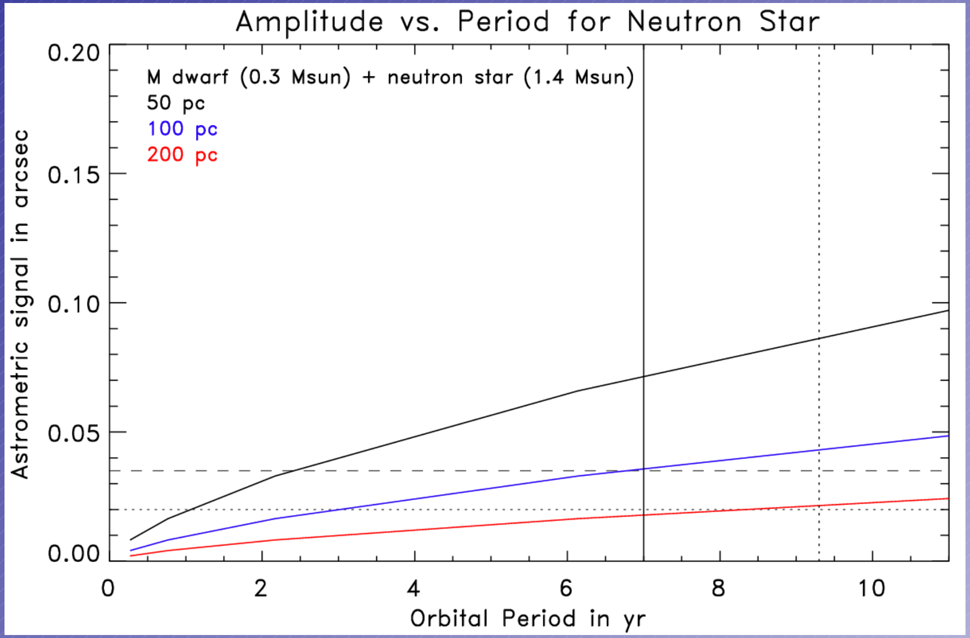
We need nearby objects!

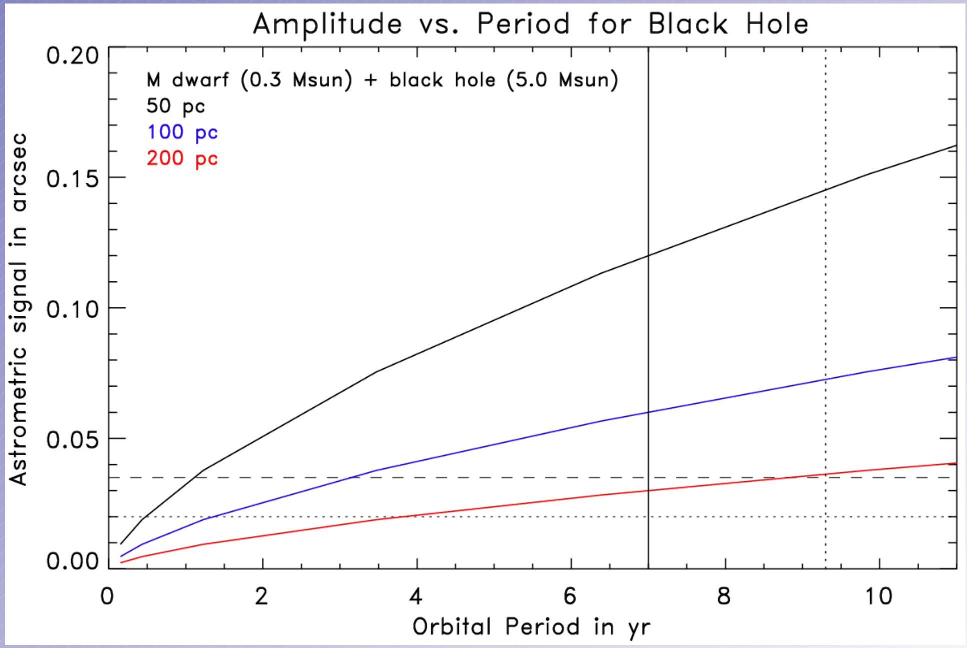
Preferably within 100pc

→ Proper motion > 50mas/yr

Binaries with larger mass ratio show larger astrometric signal

→ the most interesting ones





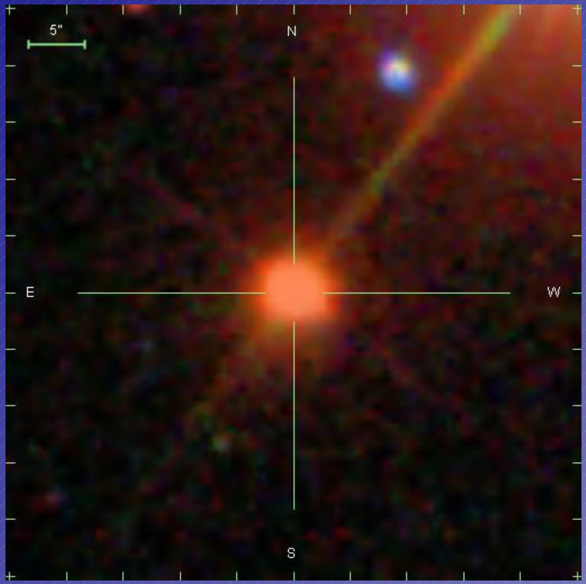
Two approaches to identify

1) Companion increases proper motion uncertainty ($\Delta\mu$) and the standard deviation of the positional residuals (σ_{Res}^2) $\rightarrow$ comparison to values of similar objects (No. of Epochs ± 5, r-mag ± 0.5)

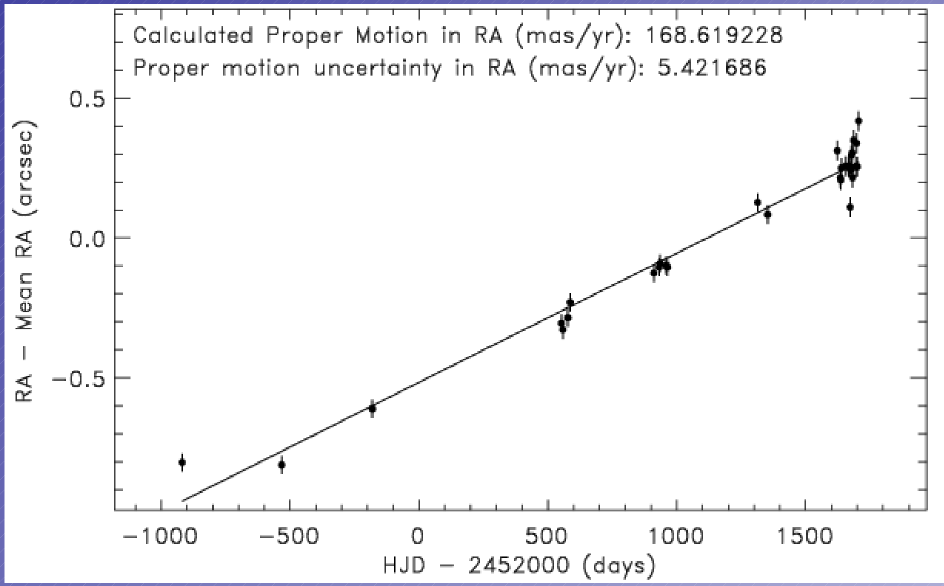
2) Binaries are periodic systems $\rightarrow$ Lomb-Scargle periodograms and sine curve-fitting in each coordinate $\rightarrow$ period equal in both coordinates

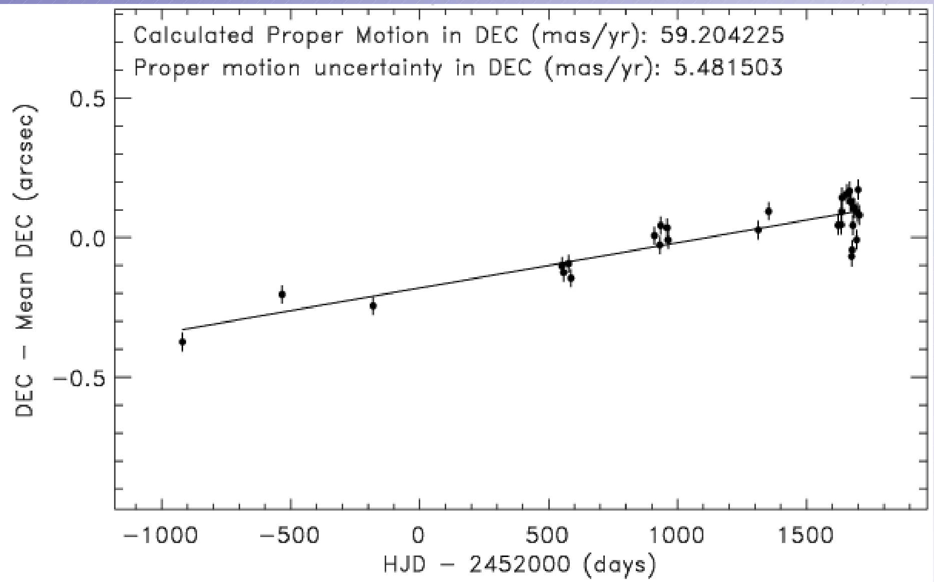
➔ Do both approaches lead to the same result?

First approach: SDSS J2341-0114

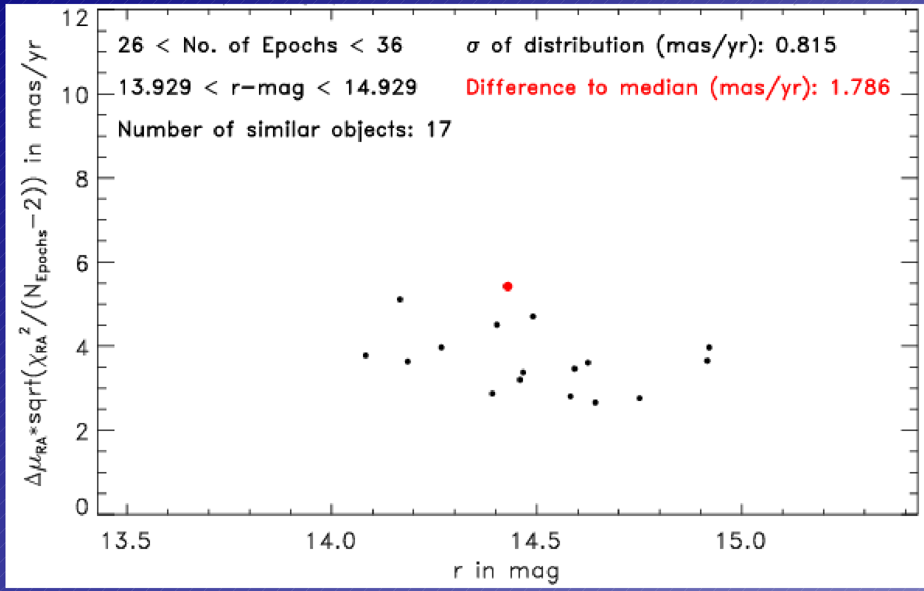


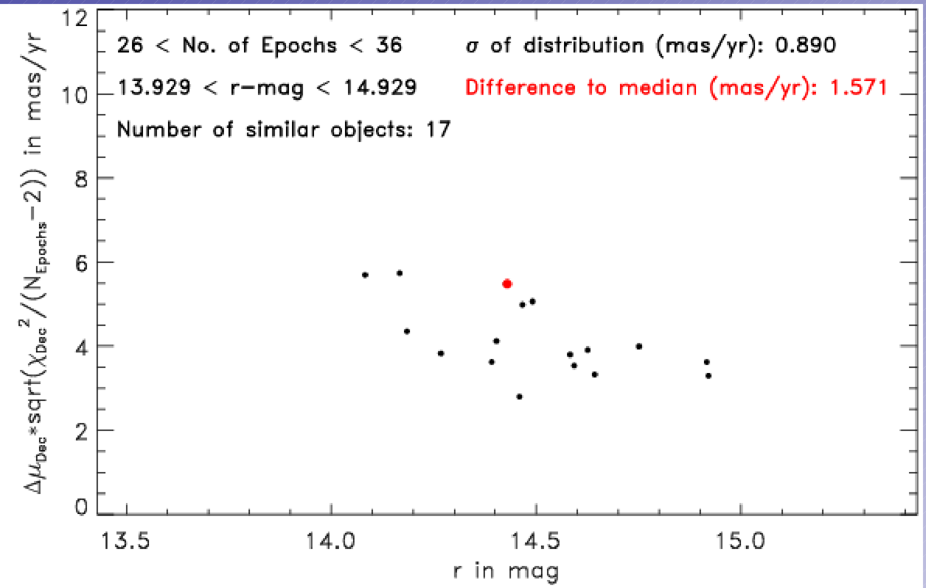
Spectral type: M2 dwarf
Distance: ~80 pc
μ_{total}: 179 mas/yr
i mag: 13.4 mag
M_i mag: 8.9 mag



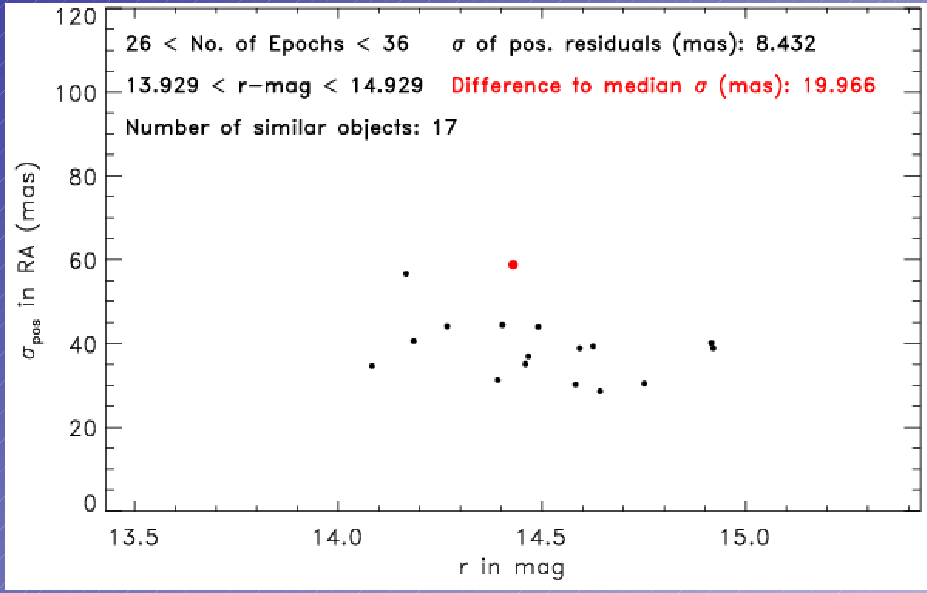


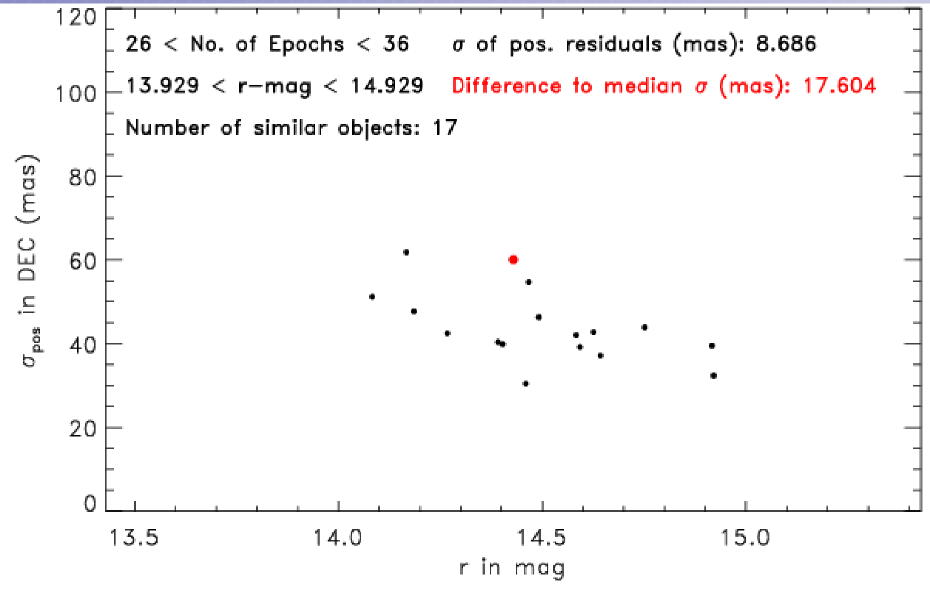
Proper motion uncertainty vs. r magnitude



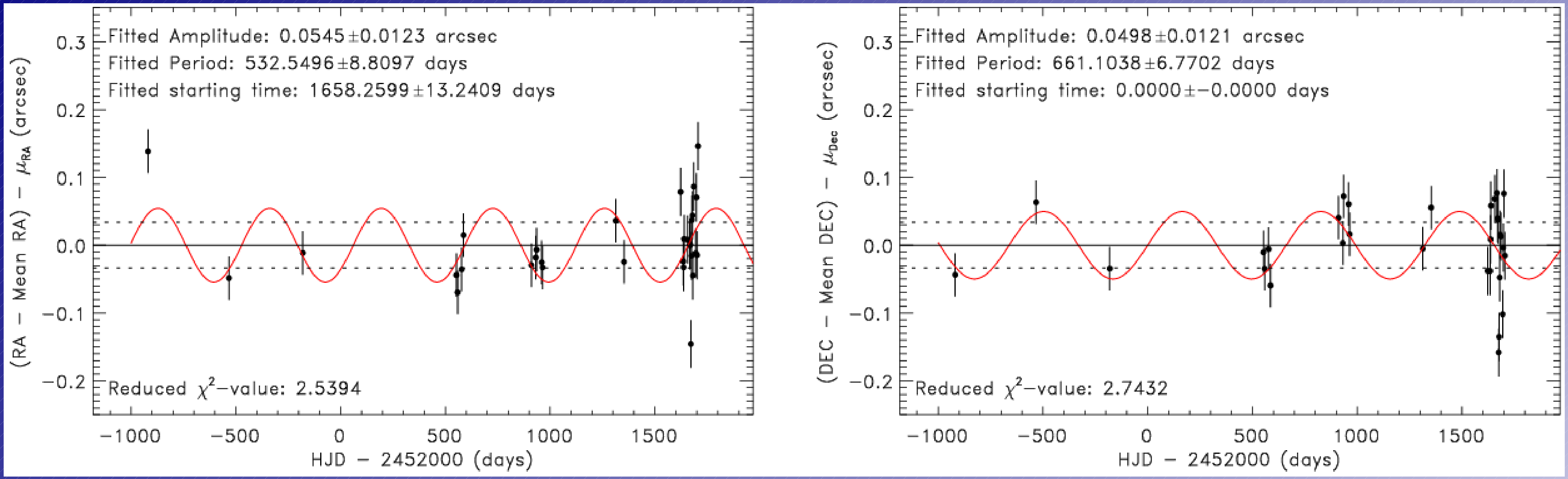


Standard deviation of positional residuals vs. r magnitude

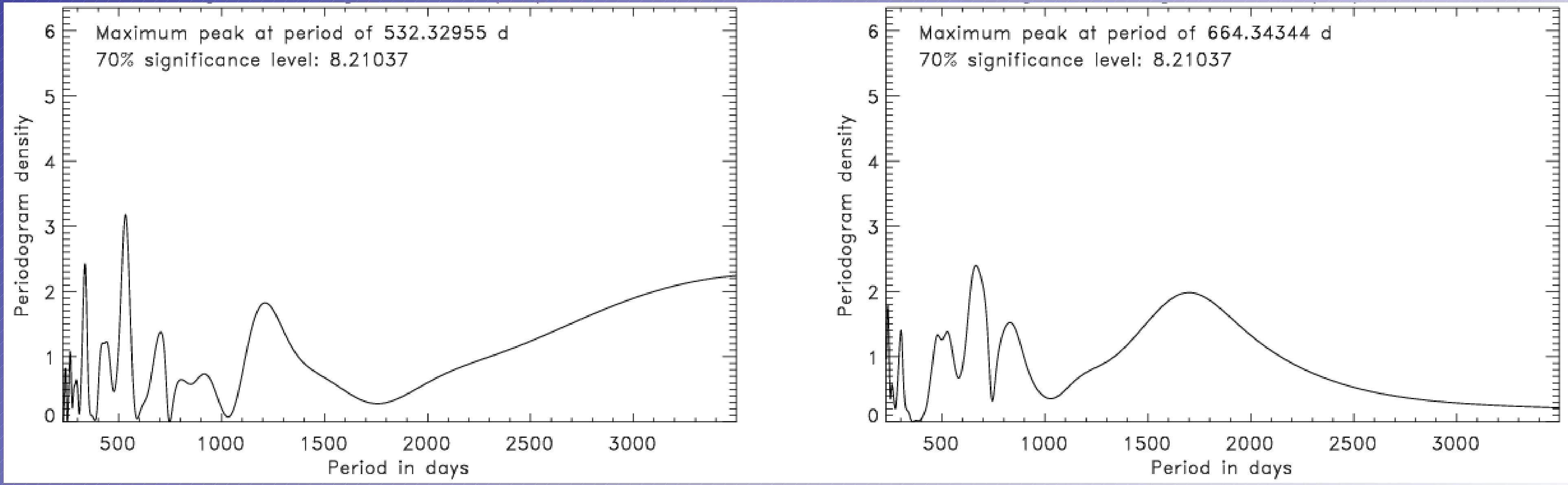




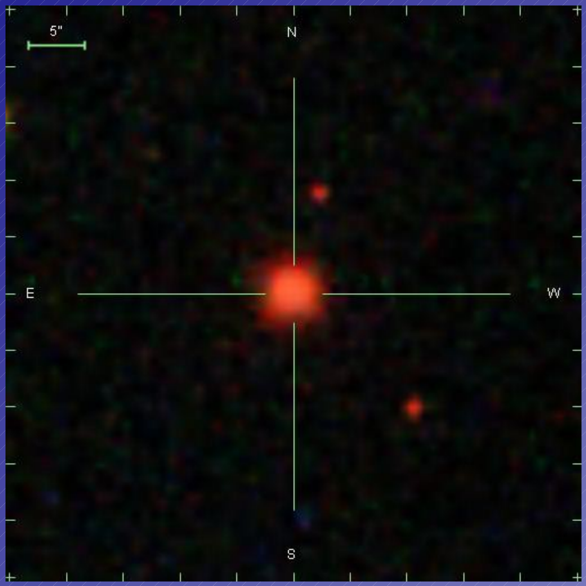
Sine-curve fitting in both coordinates



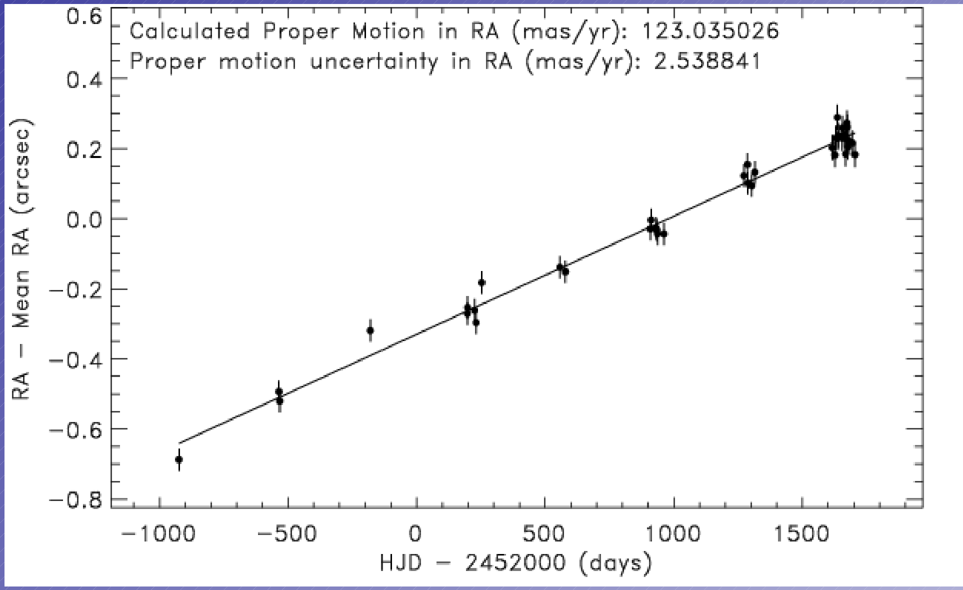
Lomb-Scargle periodogram in both coordinates

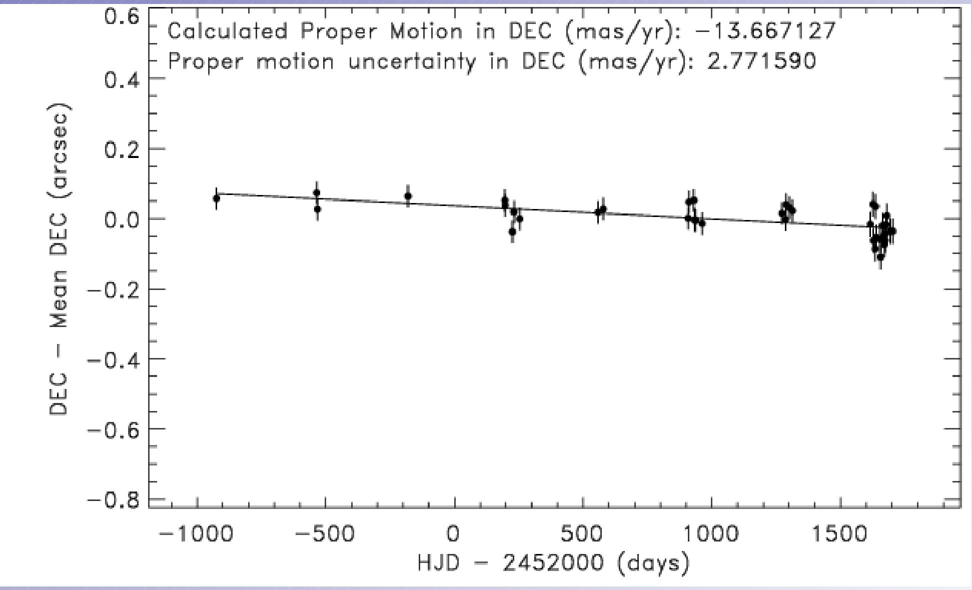


Second approach: SDSS J2325-0026

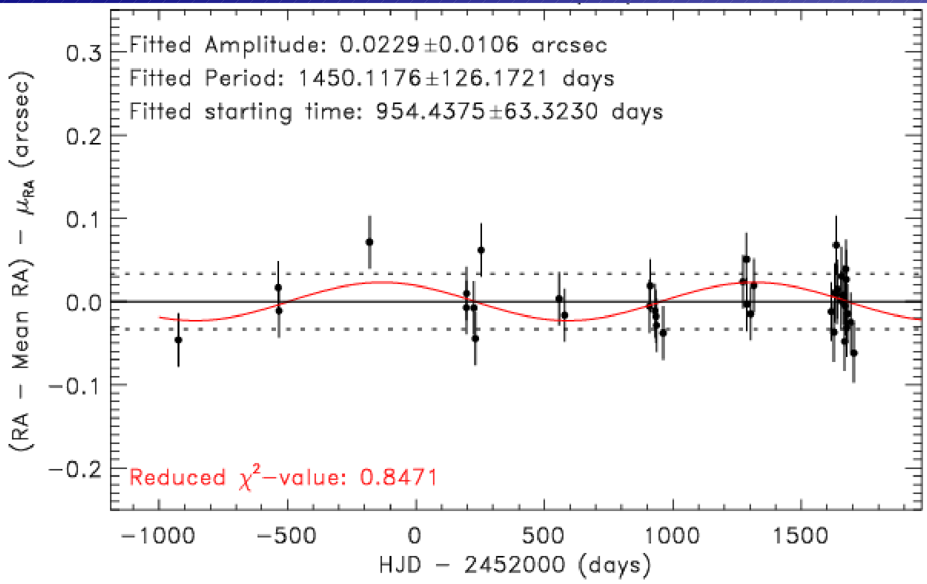


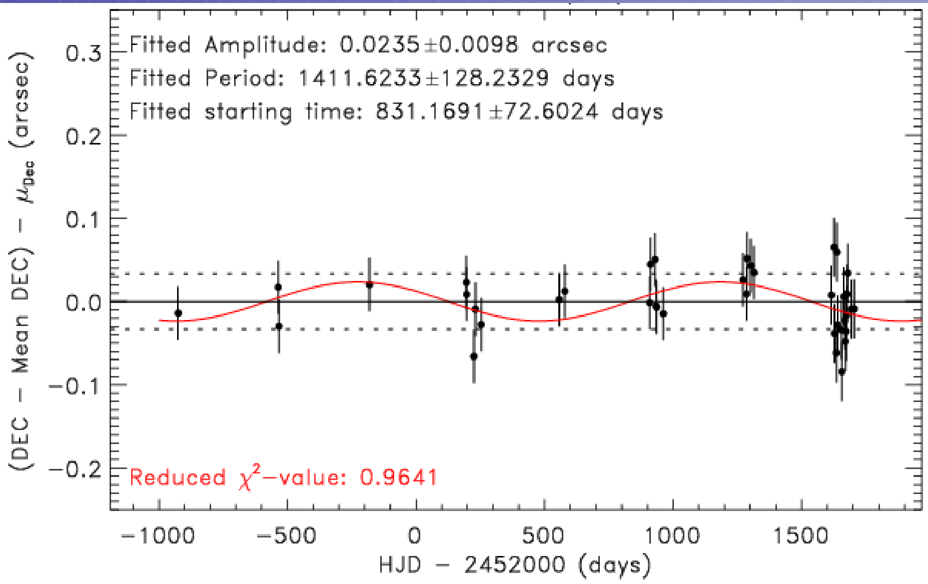
Spectral type: M4 dwarf
Distance: ~80 pc
μ_{total}: 124 mas/yr
i mag: 15.5 mag
M_i mag: 10.8 mag



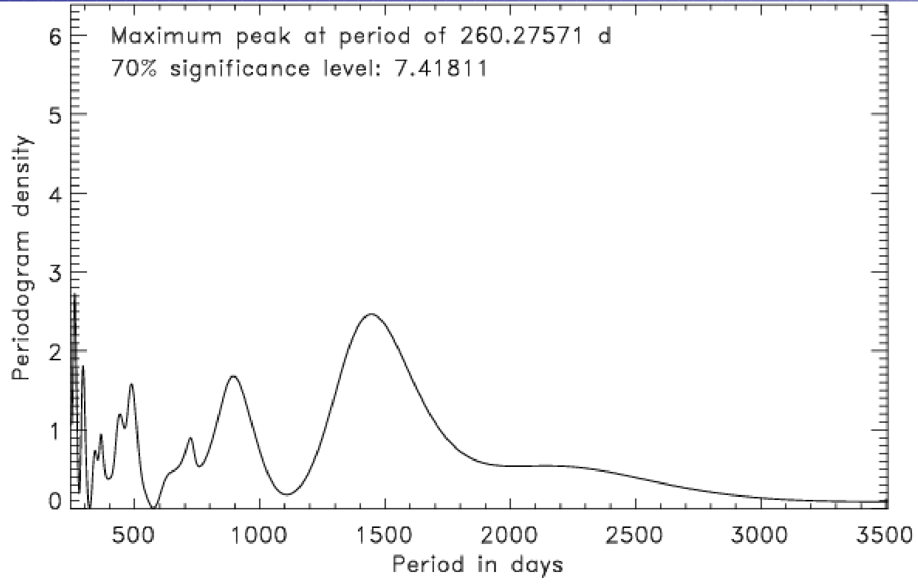


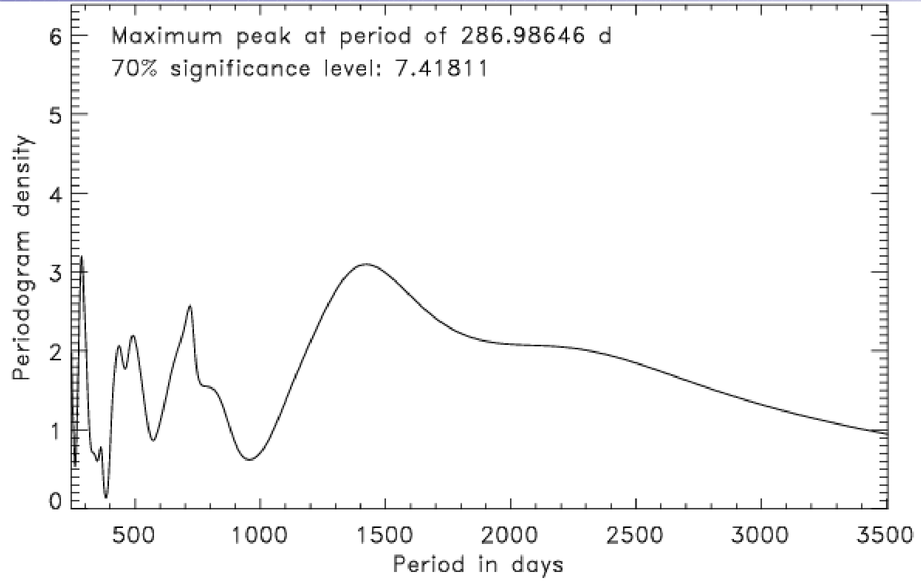
Sine-curve fitting in both coordinates



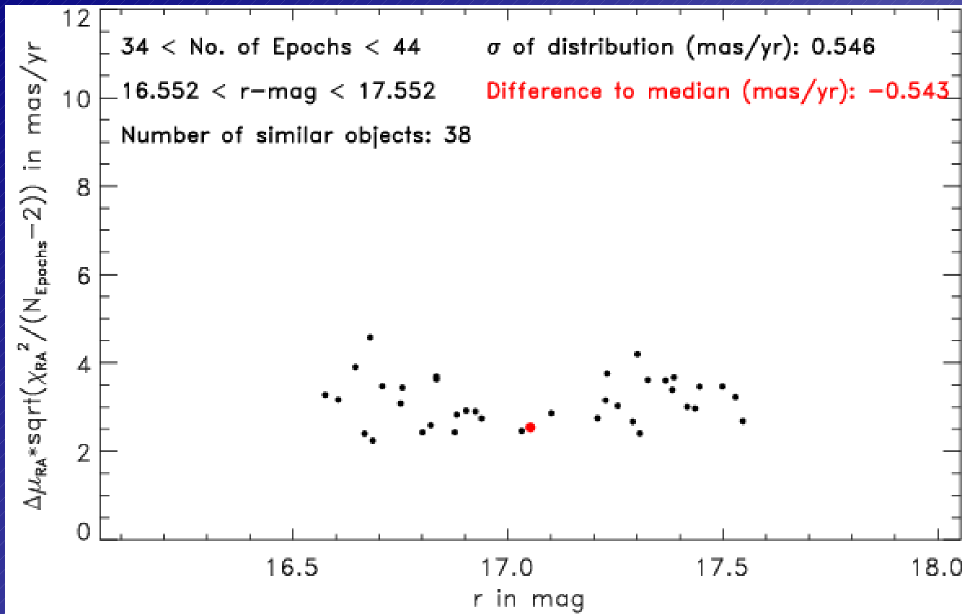


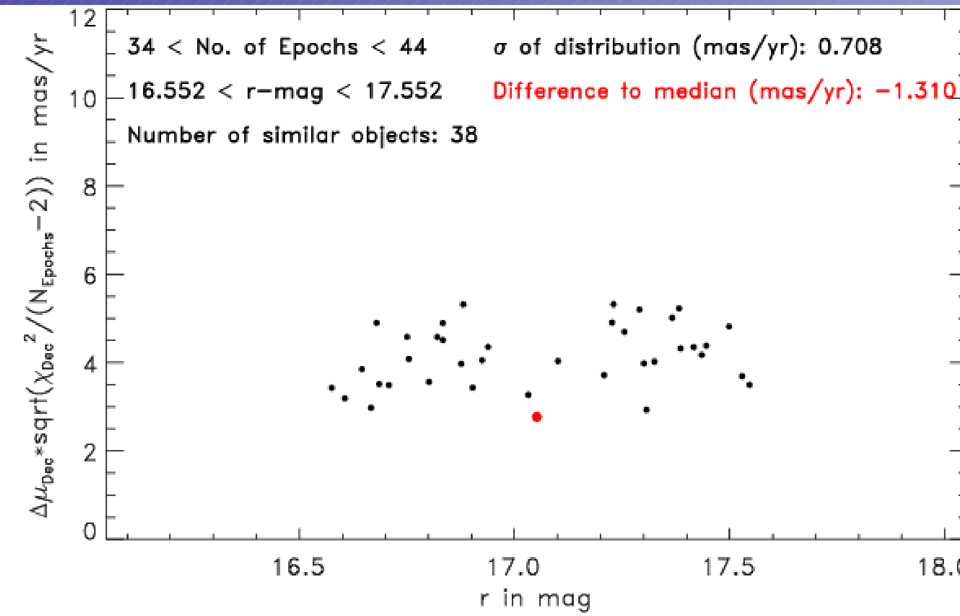
Lomb-Scargle periodogram in both coordinates



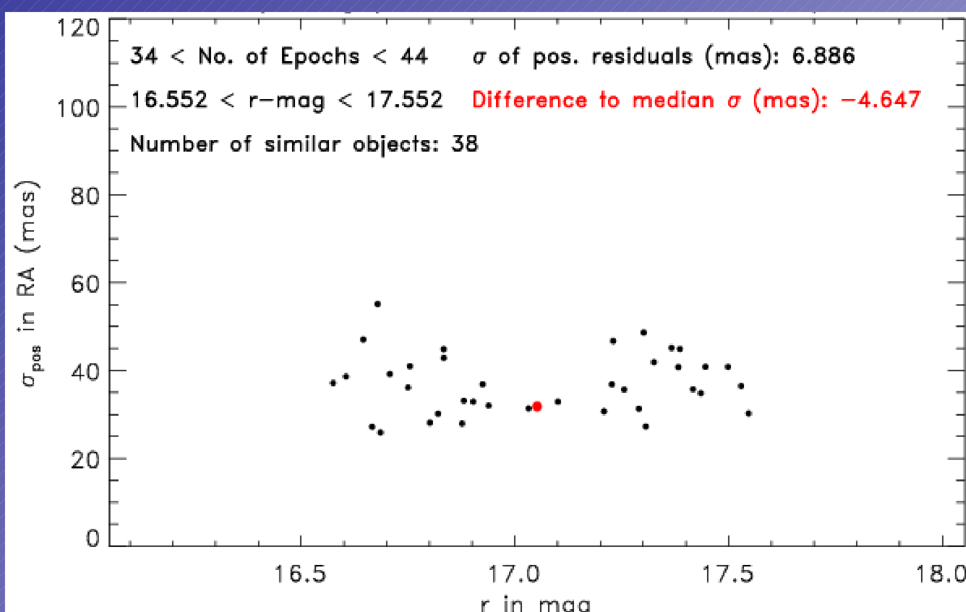


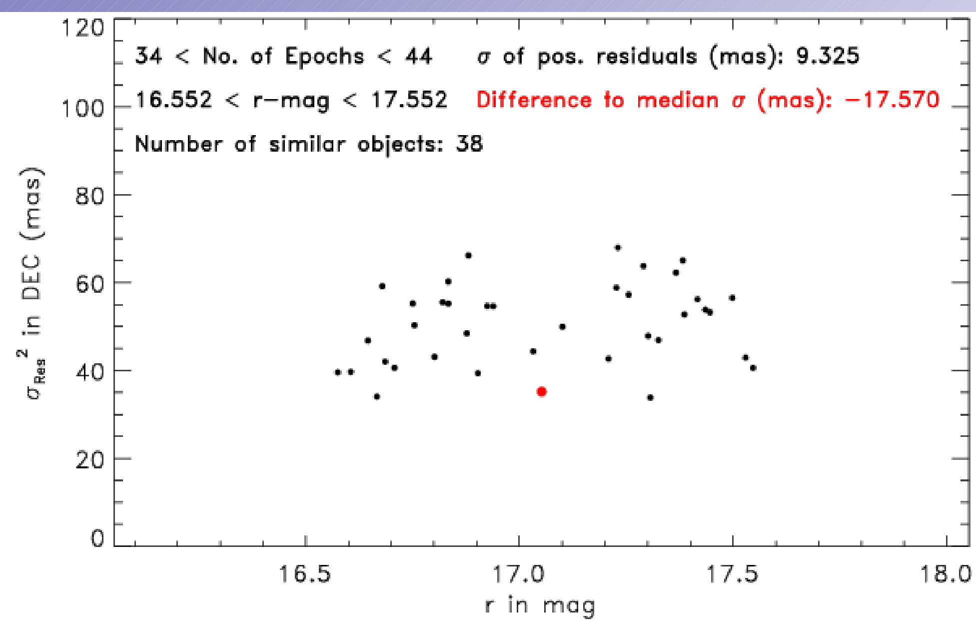
Proper motion uncertainty vs. r magnitude





Standard deviation of positional residuals vs. r magnitude





Open questions and future work

- Why do candidates show either good sine fit or are outliers in $\Delta\mu$ and σ_{Res}^2 ?
- Are the determined periods really significant?
- Resulting periods are different from sine-fit and lomb-scargle periodogram! Why?
- Orbit fit for best candidates
- Expanding data with online catalogue
- Own observations to confirm candidates

Thank you!

Artist impression by Mark Garlick (Space-Art)