1st workshop on Science with SONG: 4 more years

Exoplanets orbiting G and K giant stars

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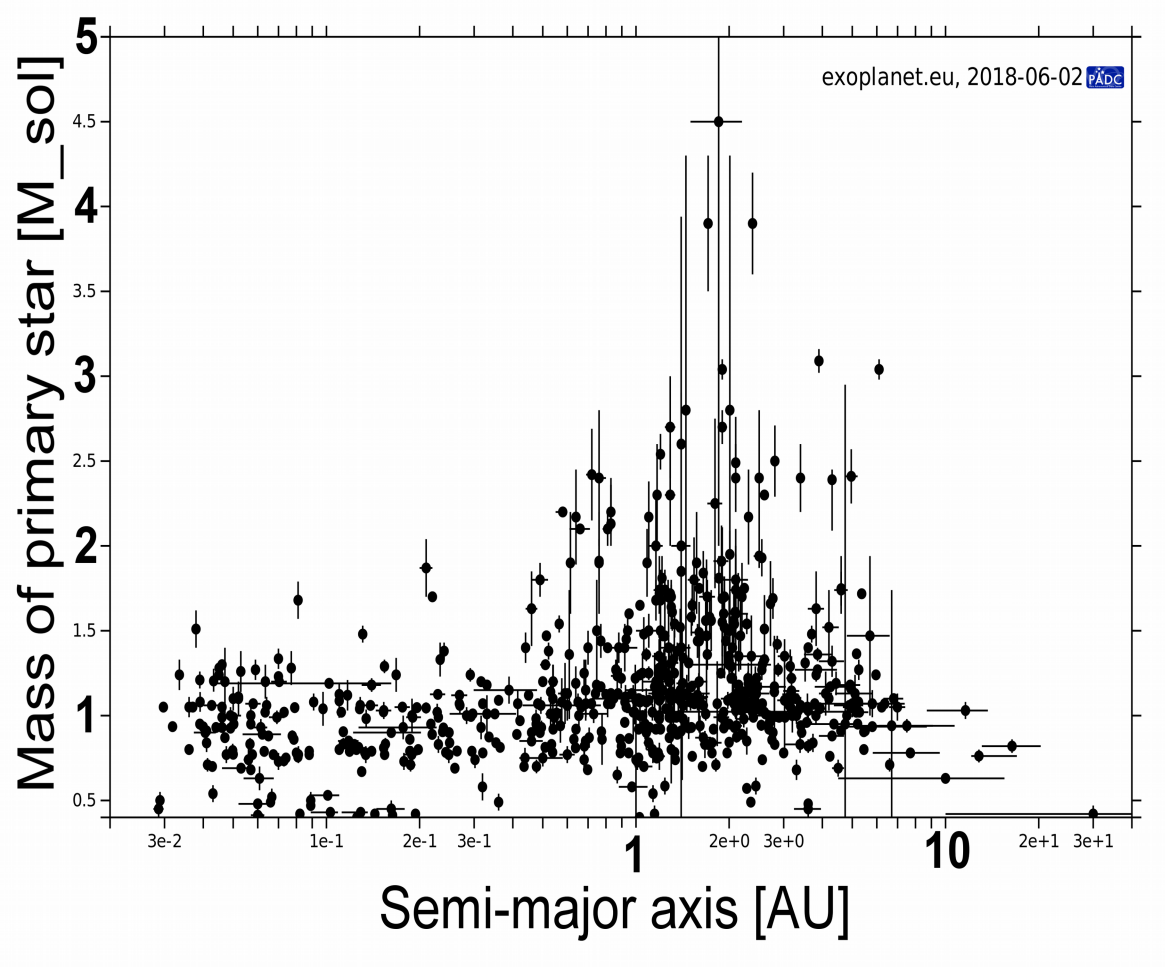
Why K/G giant stars?

- Use RV method on more massive stars
- Examine the late evolutionary stages of planetary systems
- Put further constraints on planet occurrence rates



Exoplanet.eu

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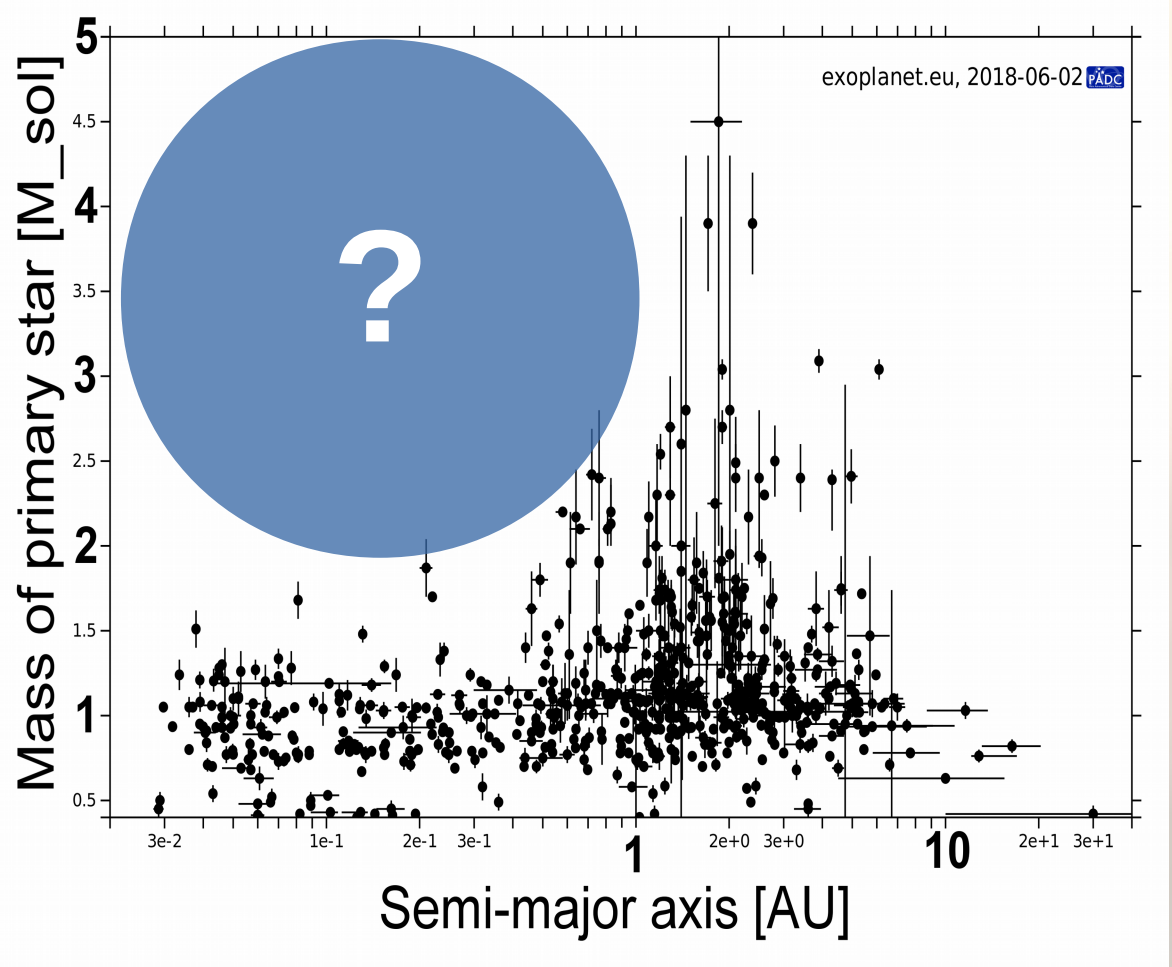
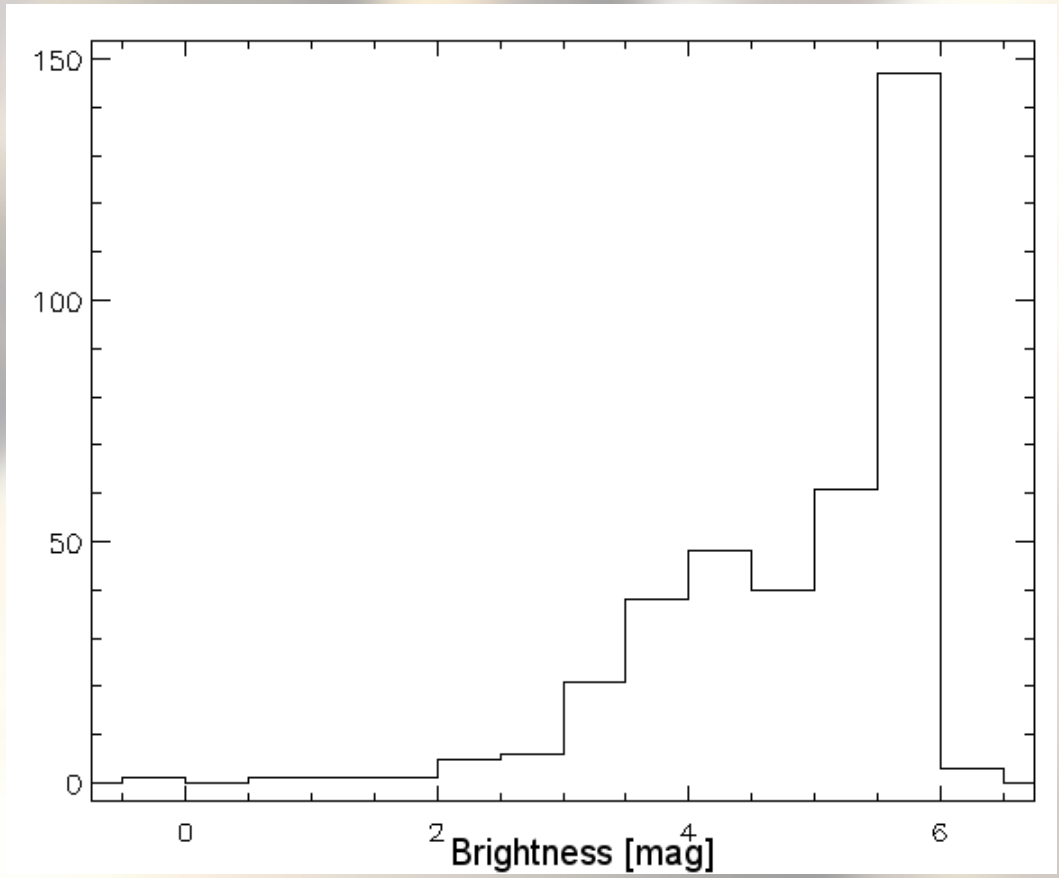
⇒ Where are the close-in planets at high stellar masses?



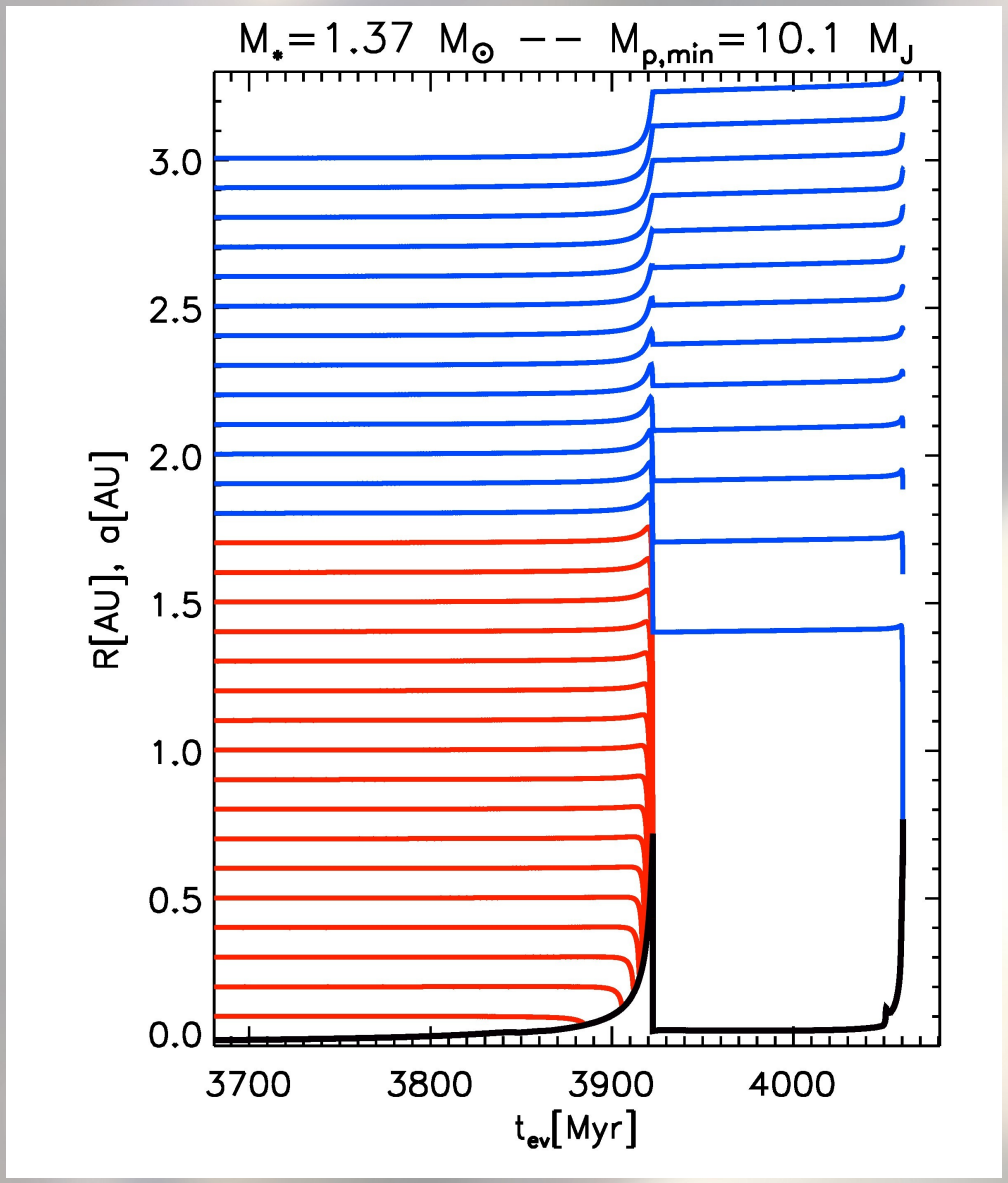
Exoplanet.eu

RV survey for exoplanets

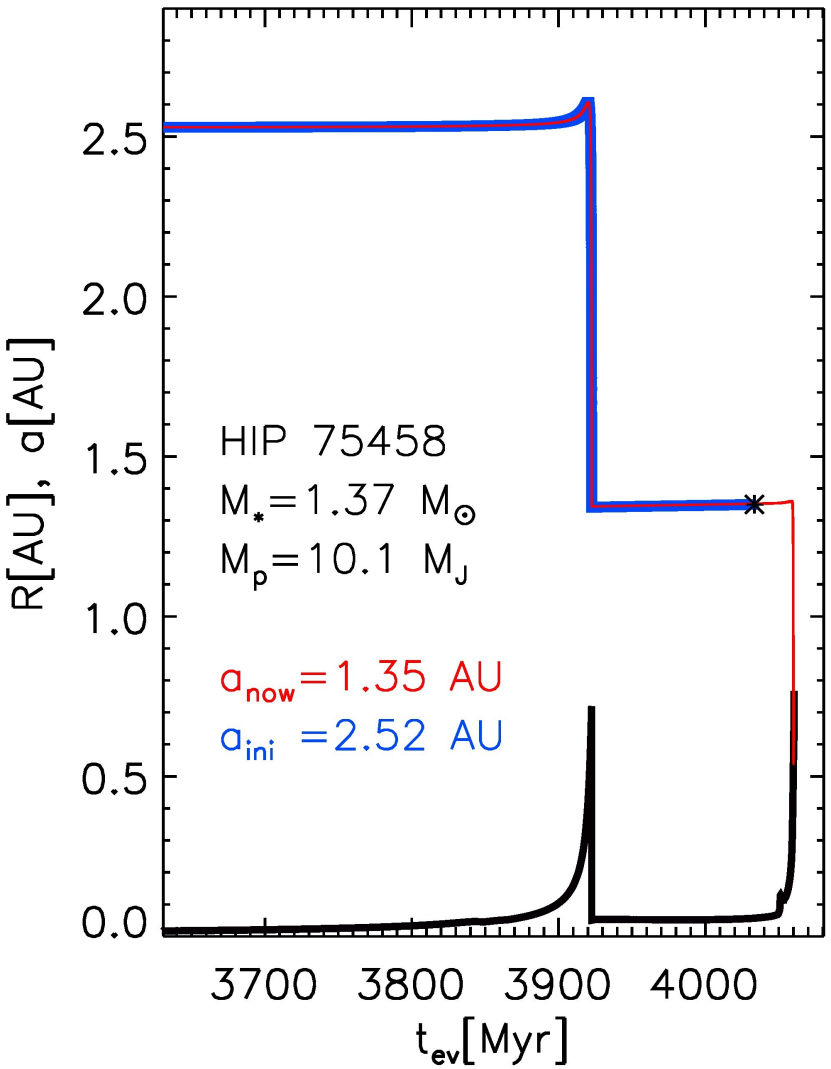
- 373 G/K giant stars
- 1999 – 2012:
  RV measurements at
  Lick Observatory
- Precision: 4 − 8 m/s
- Found 15 planets so far
  + 20 candidates
- Some planets/candidates
  in multiplanetary/binary
  systems



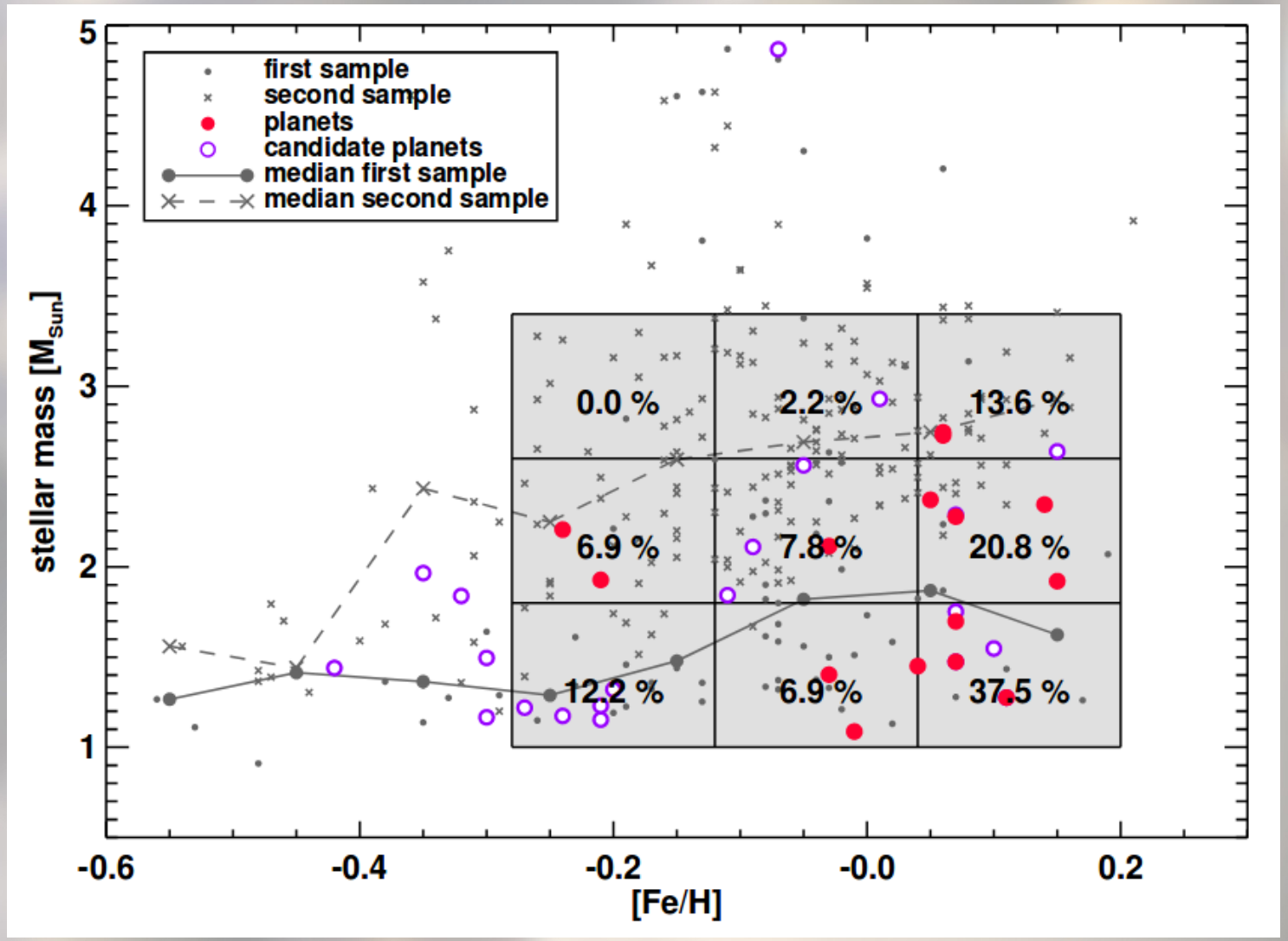
Orbit evolution



Credits: Vera Wolthoff (LSW)



Planet occurrence rate



Reffert et al. (2015)

Binary systems with planets

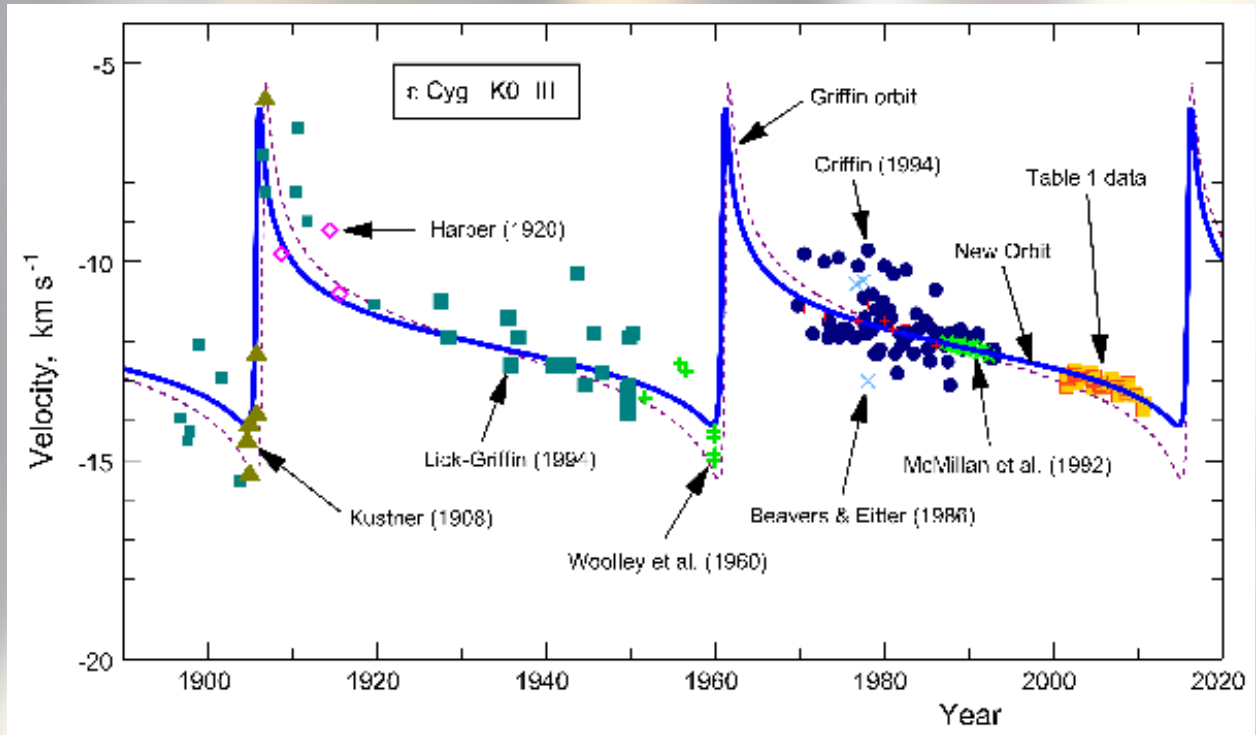
If confirmed:

Some of the closest binaries known to date to host planets

Test stone for planet formation theories

But:

Longer survey duration!



Gray (2015)

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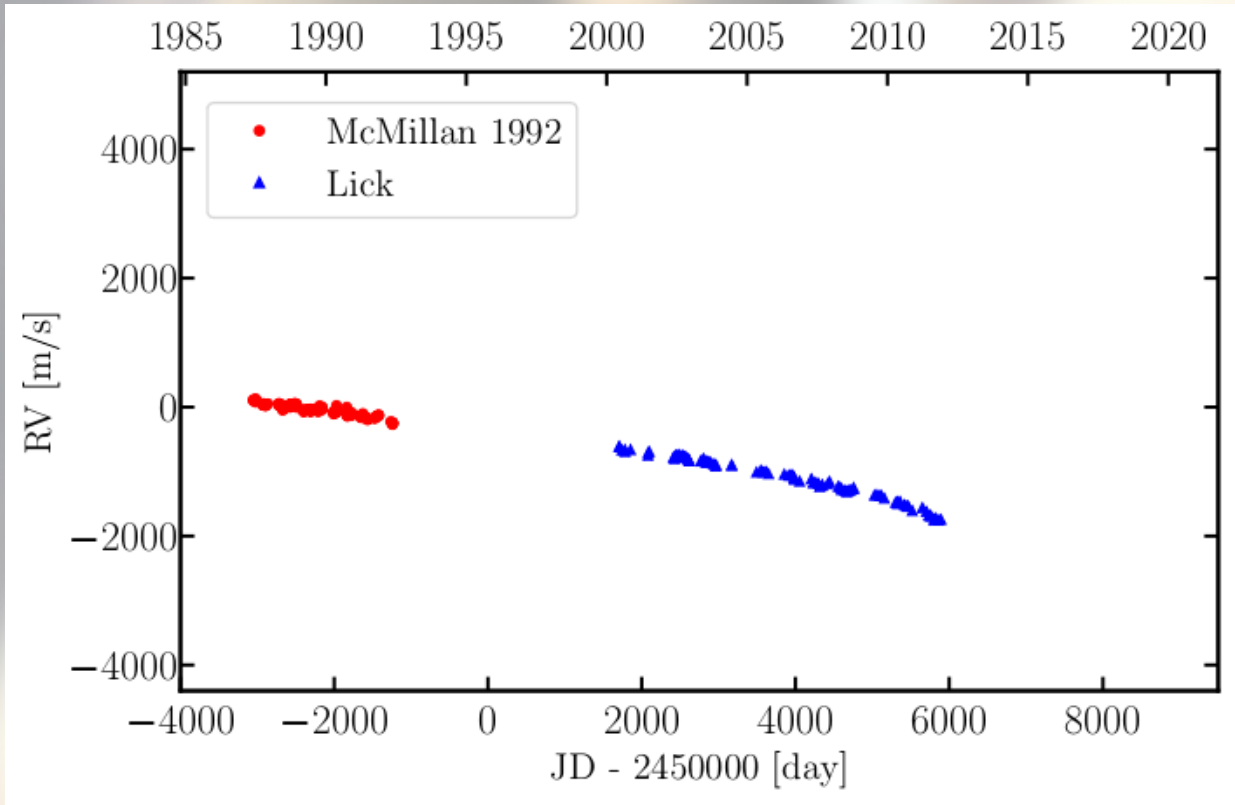

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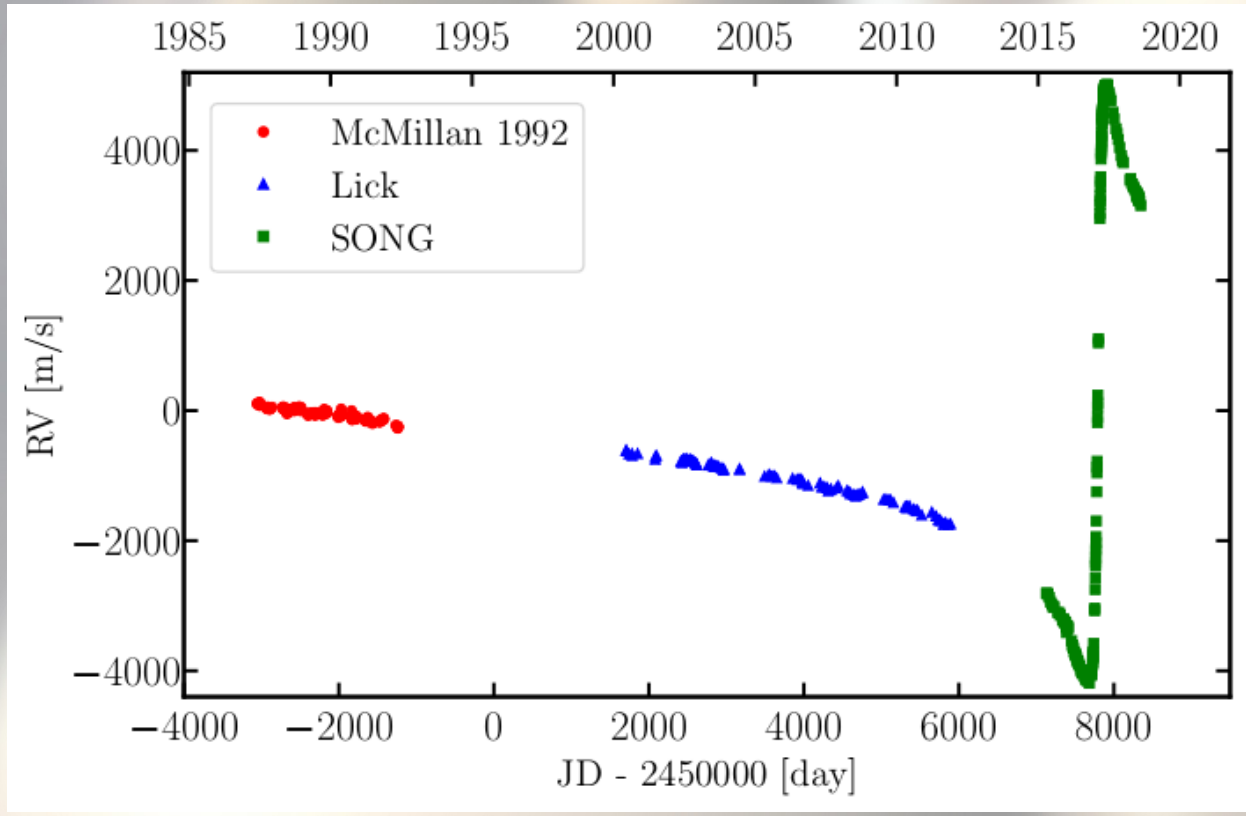


ε Cyg: A very eccentric binary!

Binary period: 55.6 yr

$e = 0.93 \pm 10^{-4}$

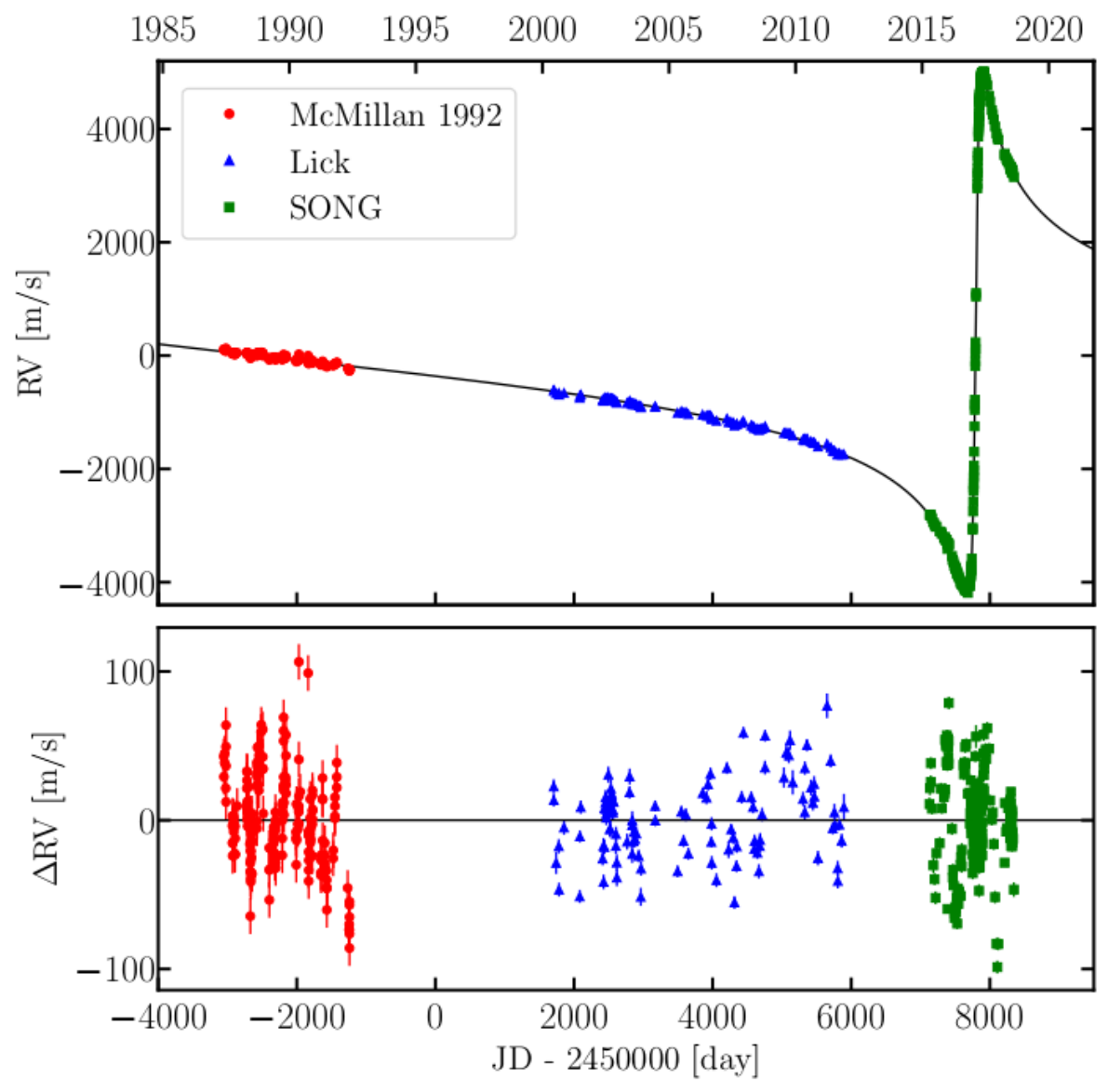
With $M_A = 1.2\ M_{sol}$:

$M_B \sin i \approx 0.3\ M_{sol}$

$a_B \approx 16.7$ AU

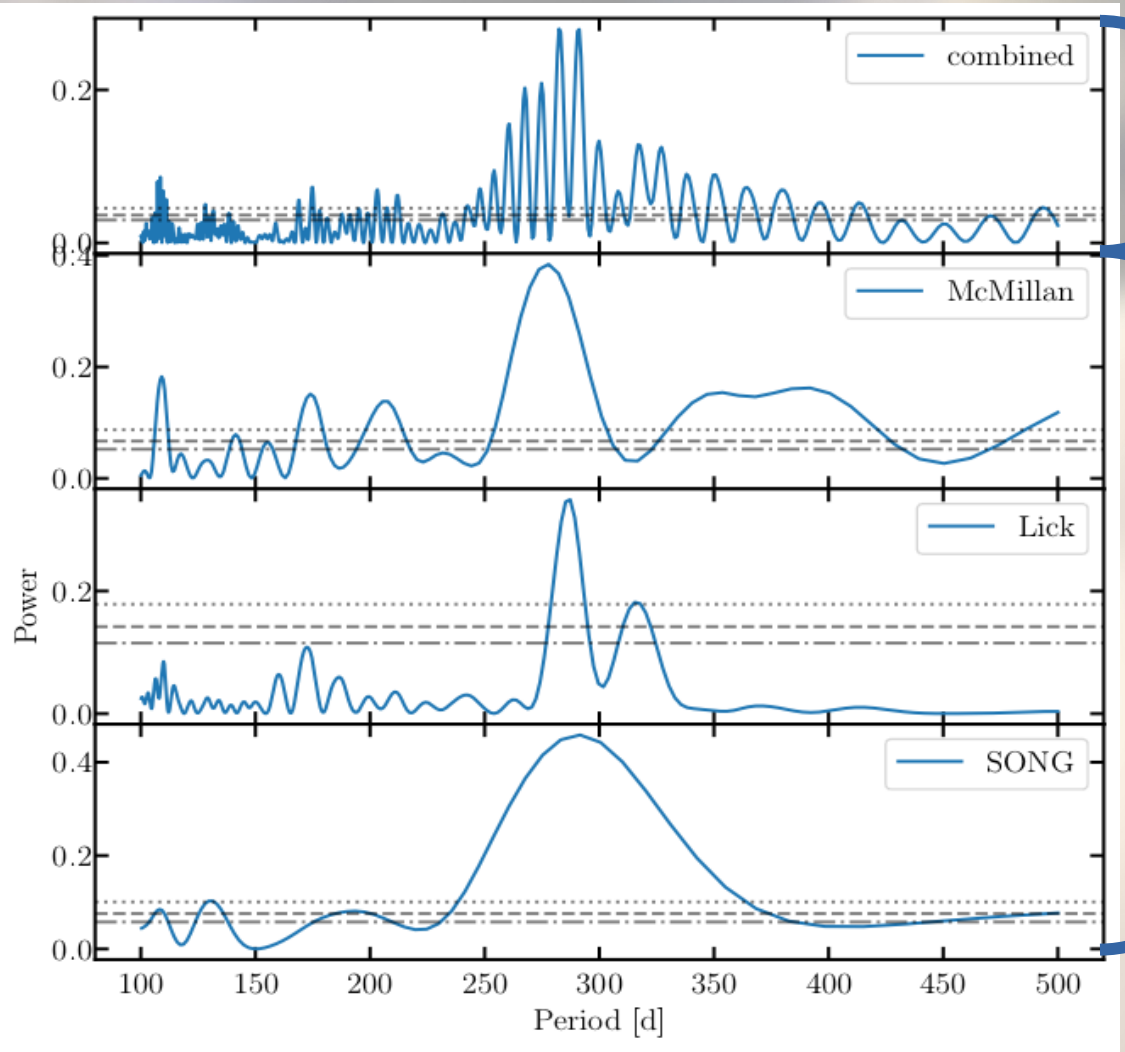
$r_{min} \approx 1.2$ AU

$r_{max} \approx 32.2$ AU



ε Cyg: A second companion?

Periodogram of residuals of binary fit



Two peaks:

~ 282 d

~ 291 d

Additional RV variations

275 ~ 290 d

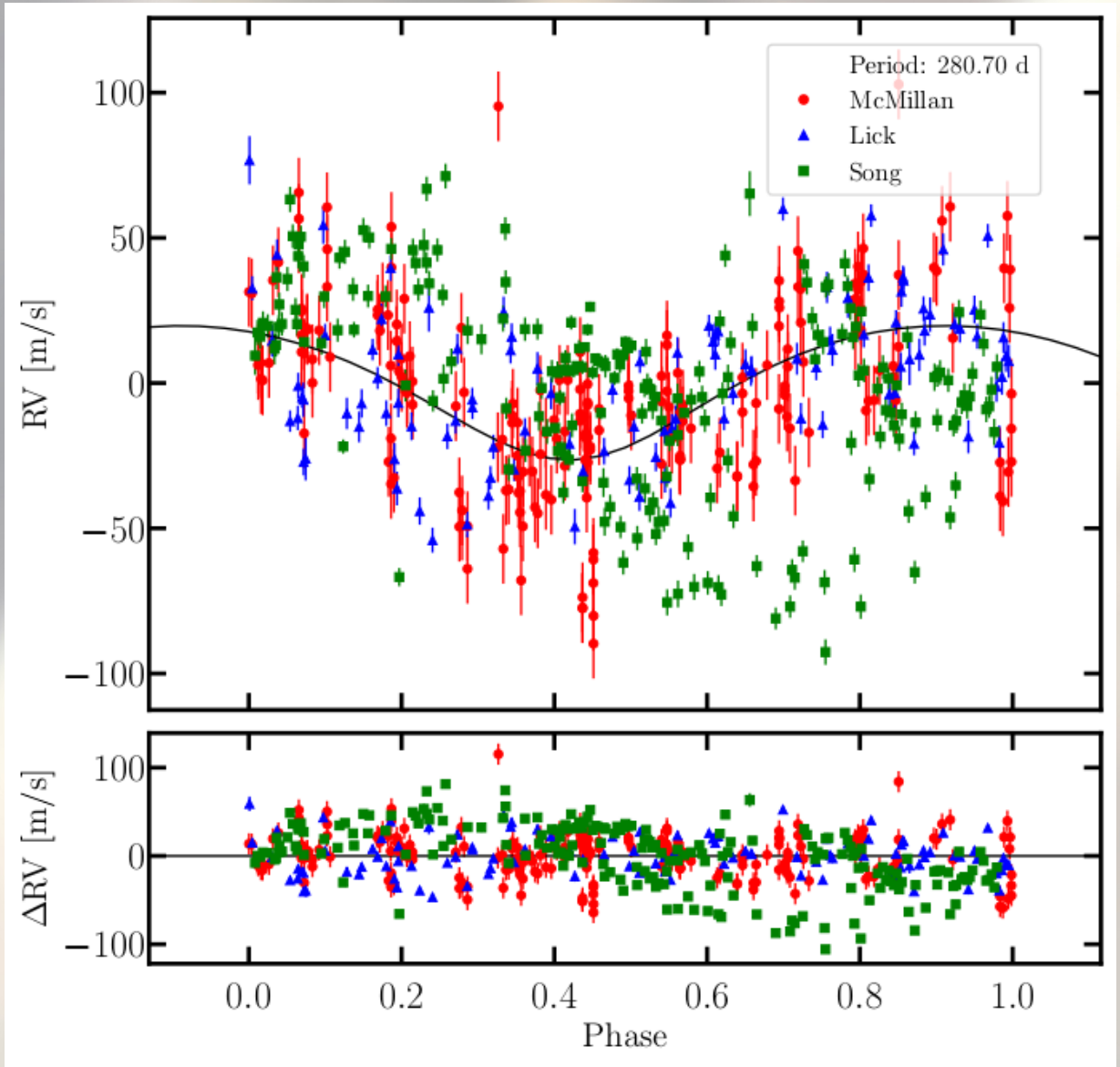
ε Cyg: A second companion?

Planet period: 280.7 d

$e \approx 0.12$

$M_b \sin i \approx 0.84\ M_J$

$a_b \approx 0.89$ AU



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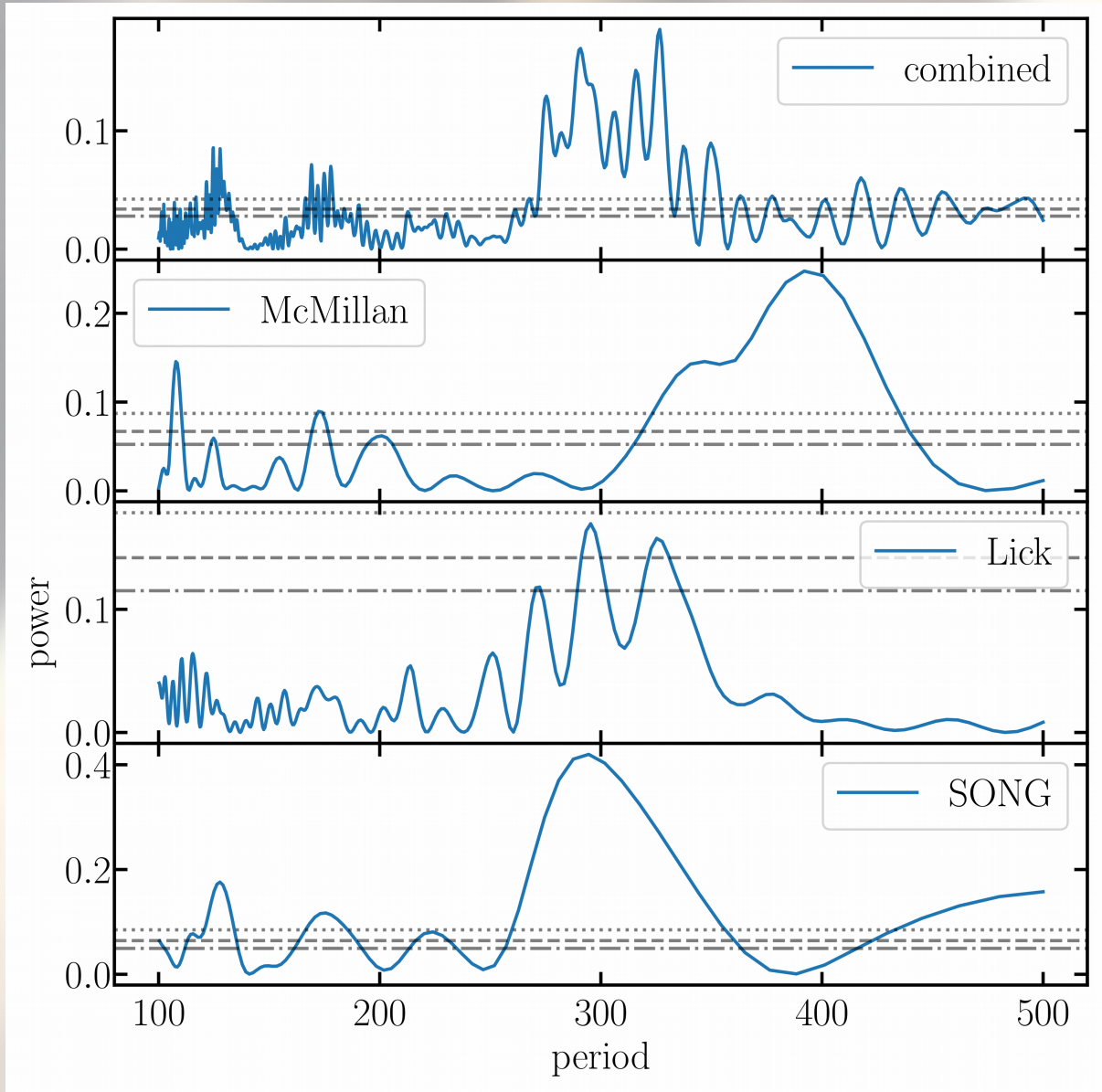
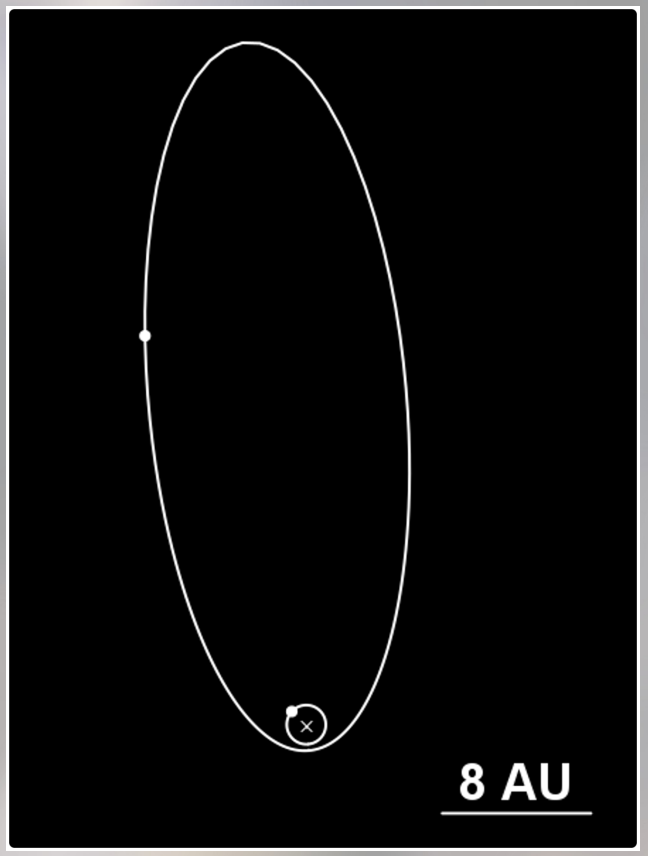
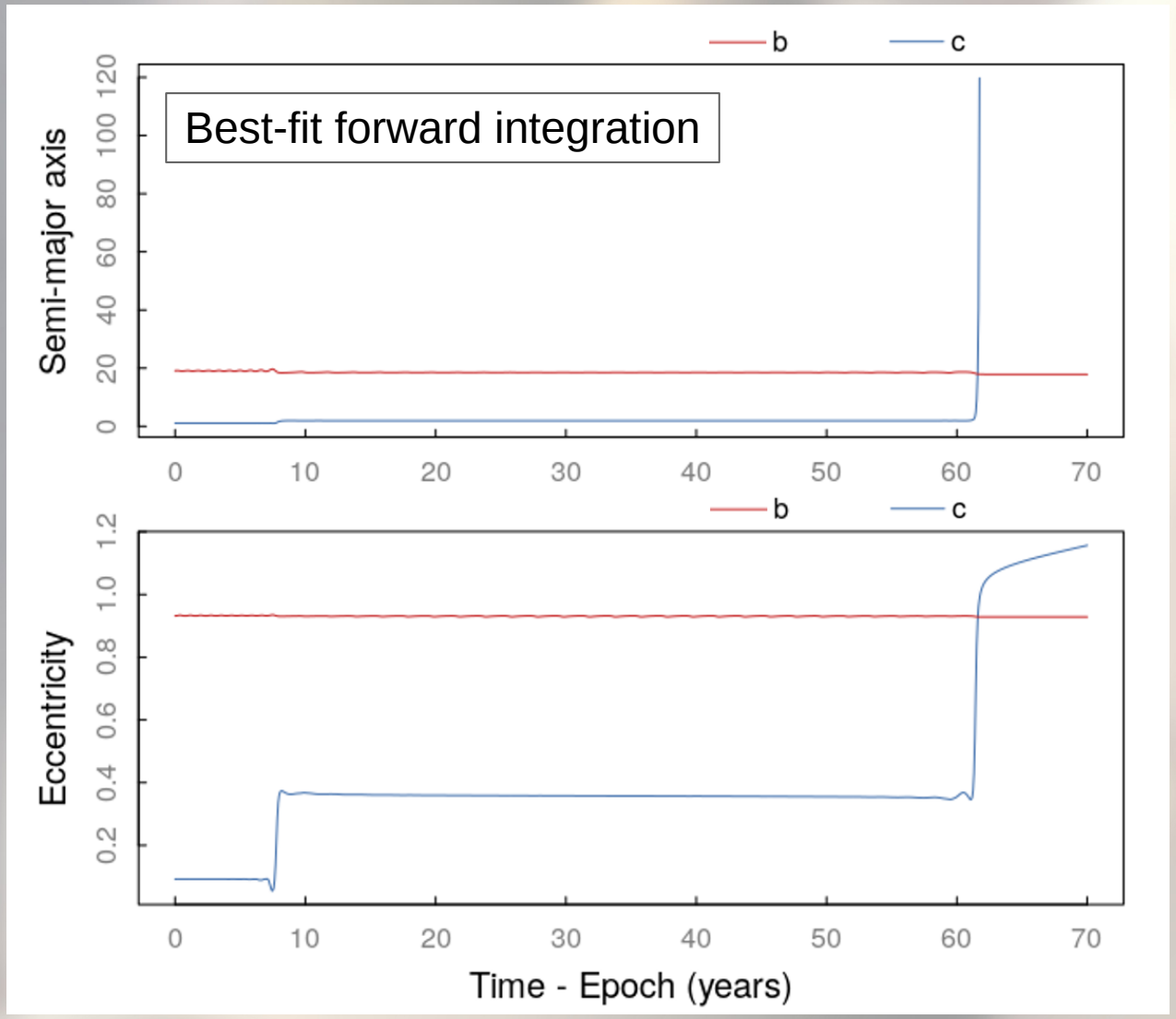


ε Cyg: A second companion?

Would it be stable?





ε Cyg: A second companion, or…

…stellar oscillations due to heartbeat phenomenon?

⇒ very unlikely: $r_{min}/R_* \approx 24 > 10$

…oscillatory convective modes (Saio et al., 2015)?

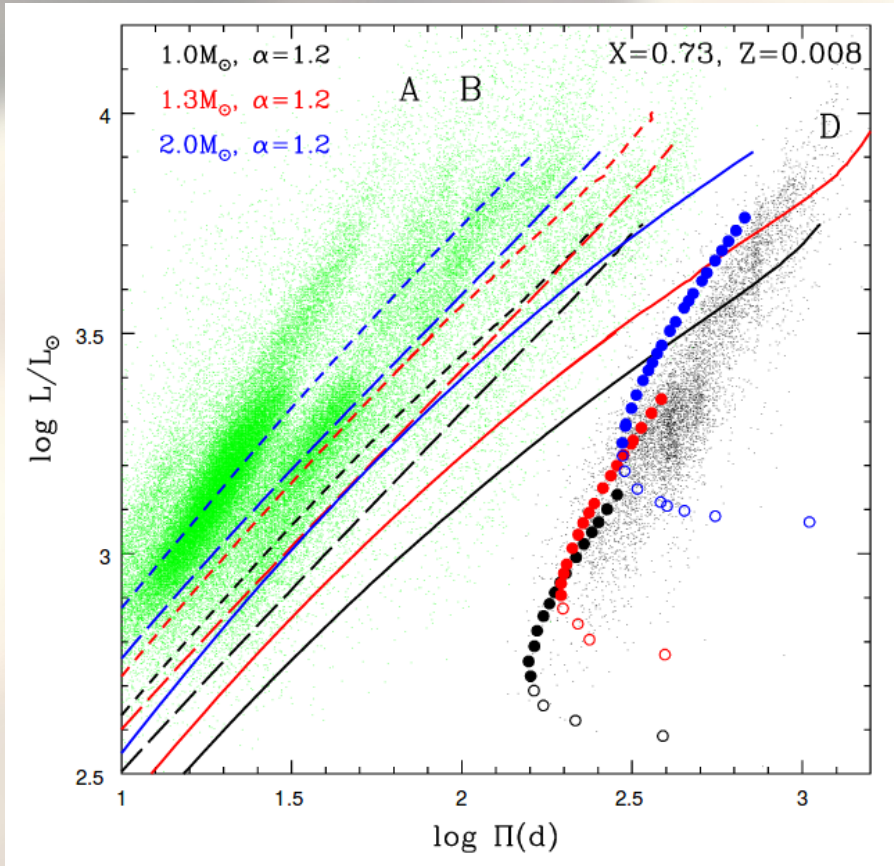
⇒ possibly not: $L_* \approx 62\ L_{sol}$

…instrumental systematics?

⇒ amplitude too large

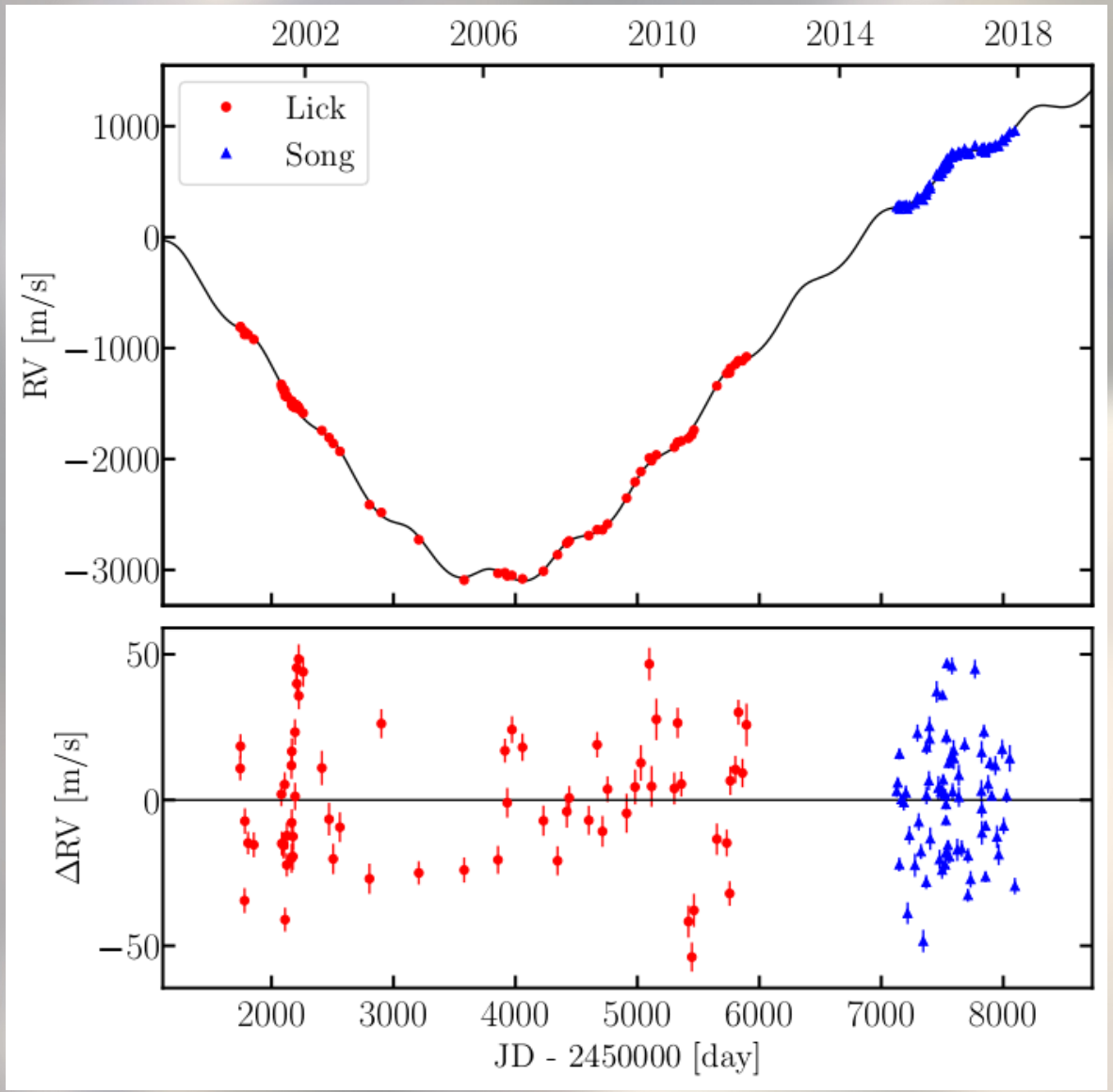
…stellar rotation + activity?

⇒ nothing visible in photometry



Saio et al. (2015)

Binary + planet

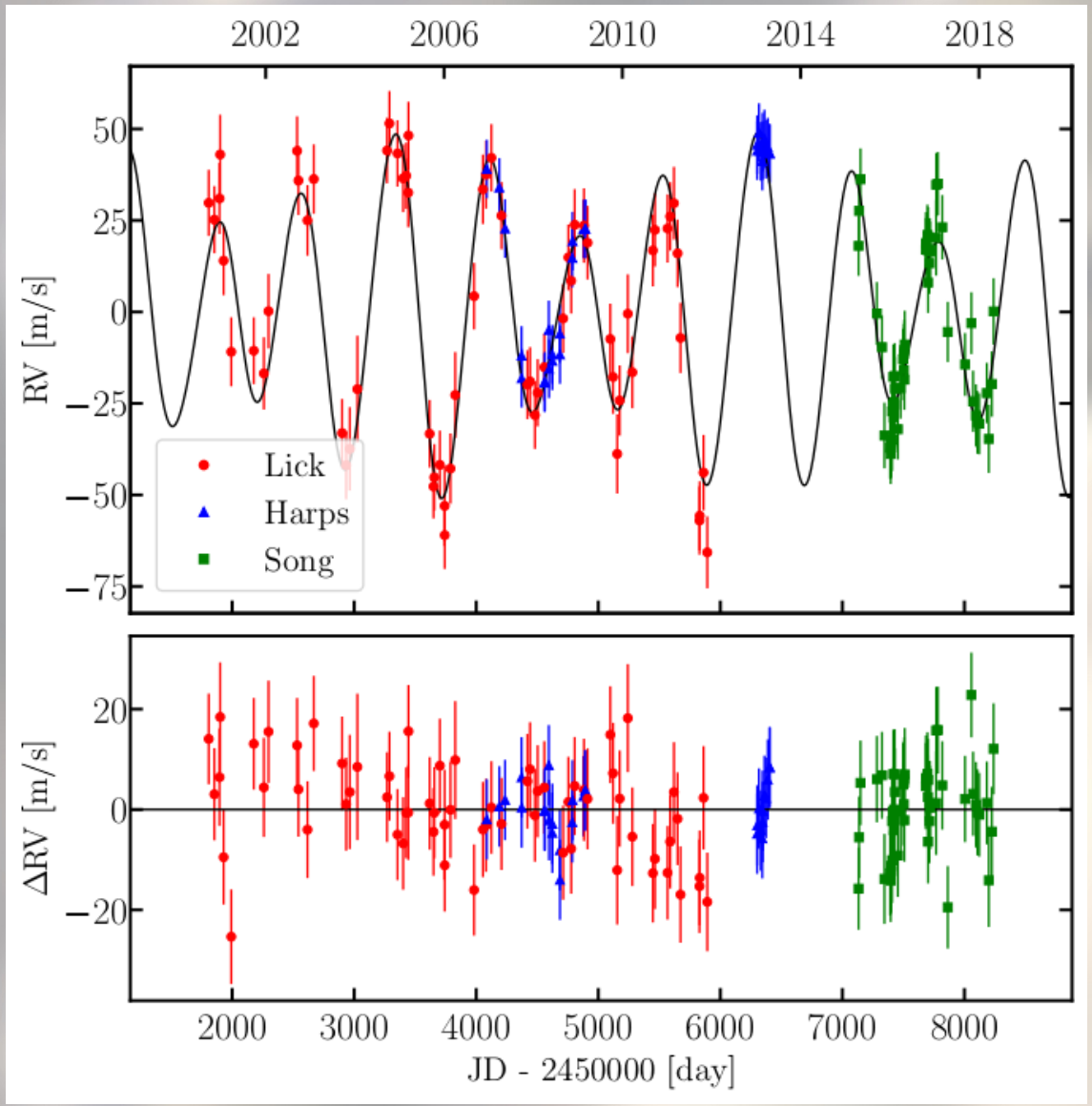


$P_1 \approx 38 \pm 5.5$ yr

$P_2 = 637$ d

How long is the binary's period?

Two close-by planets



$P_1 \approx 740$ d

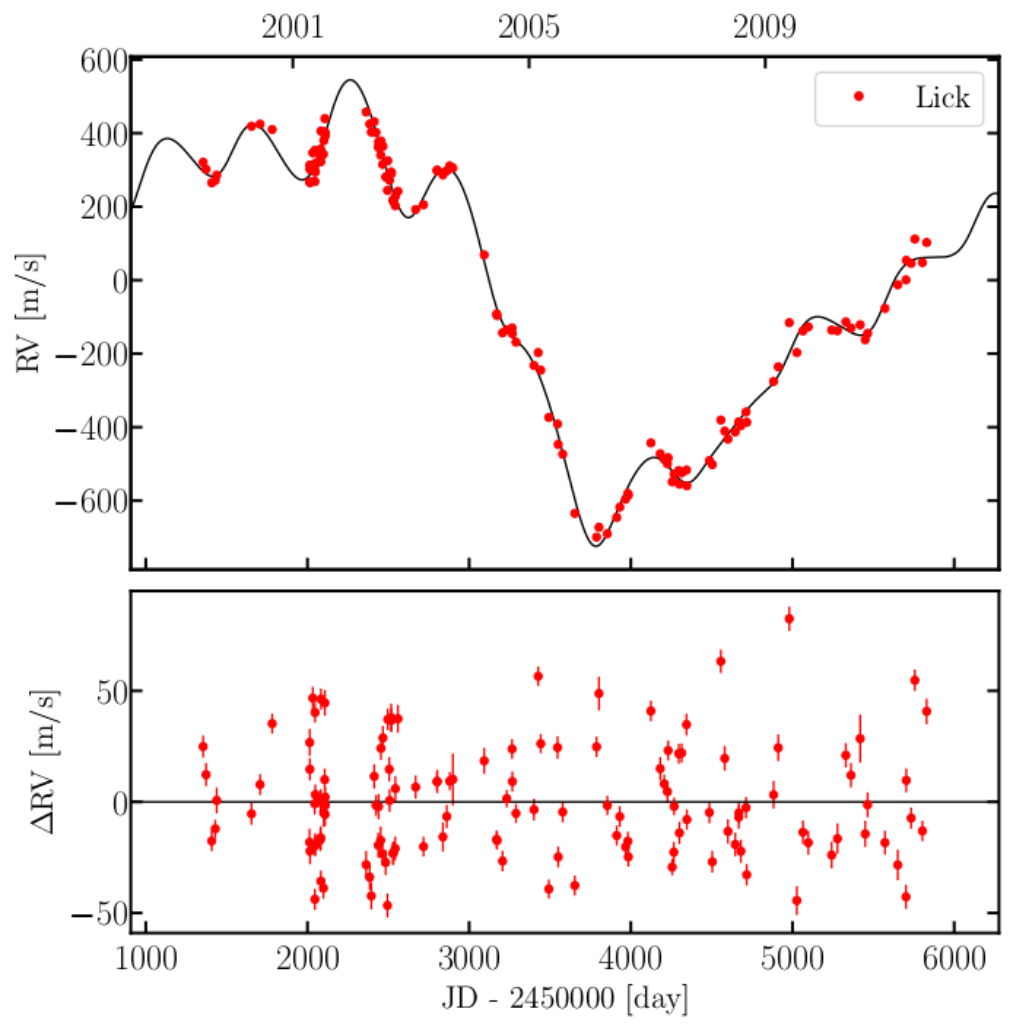
$P_2 \approx 1000$ d

$M_1 \sin i \approx 2.0\ M_J$

$M_2 \sin i \approx 0.9\ M_J$

What are the system dynamics?

A densely packed quadruplet



$P_1 \approx 16$ yr $\quad P_2 \approx 945$ d

$P_3 \approx 652$ d $\quad P_4 \approx 576$ d

$M_1 \sin i \approx 42\ M_J$

$M_{2,3,4} \sin i > 1\ M_J$

How long is the binary's period?
What are the system dynamics?

Summary & Conclusions

Planets around K/G giants → Evolution of planetary systems

Planets in binaries → Planet formation

Multiplanetary systems → Orbit dynamics

⇒ Longer survey duration necessary
⇒ High-precision RV measurements
⇒ Data needs to be reliable

} **SONG**

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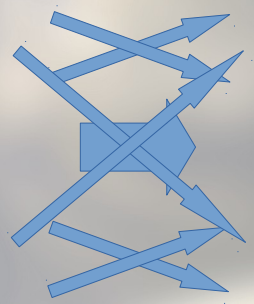

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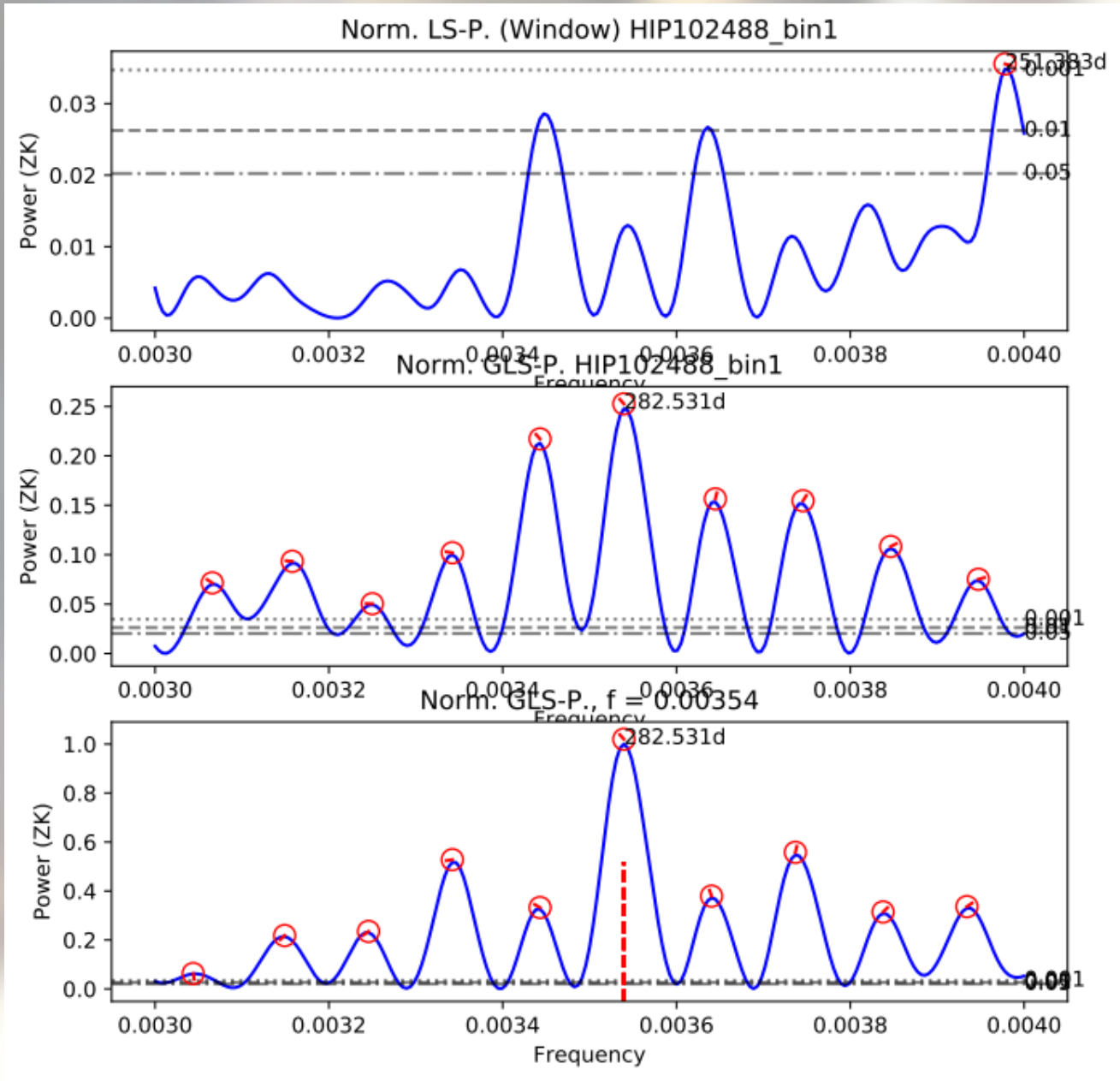
} **SONG**


Thank
you!

ε Cyg: Are the signals real?

Following
R. Dawson &
D. Fabrycky
(2010)



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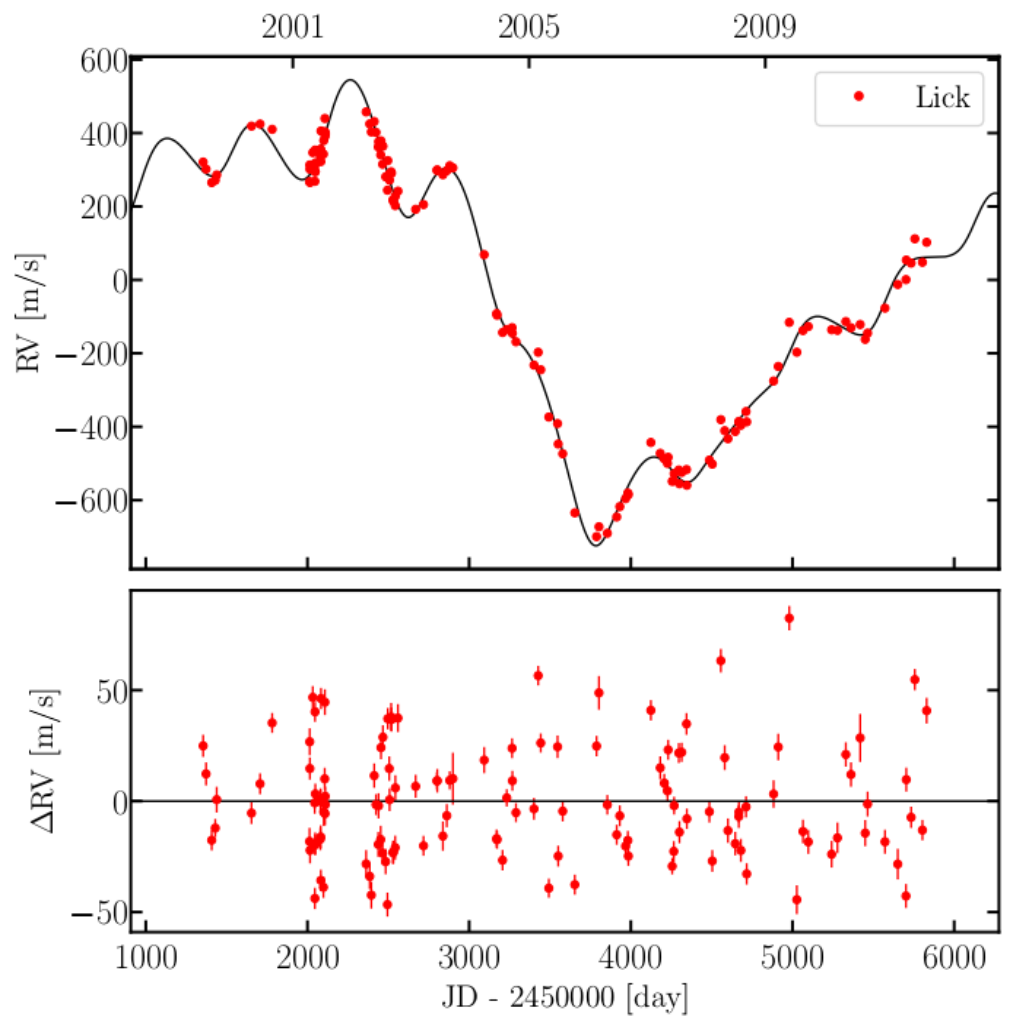

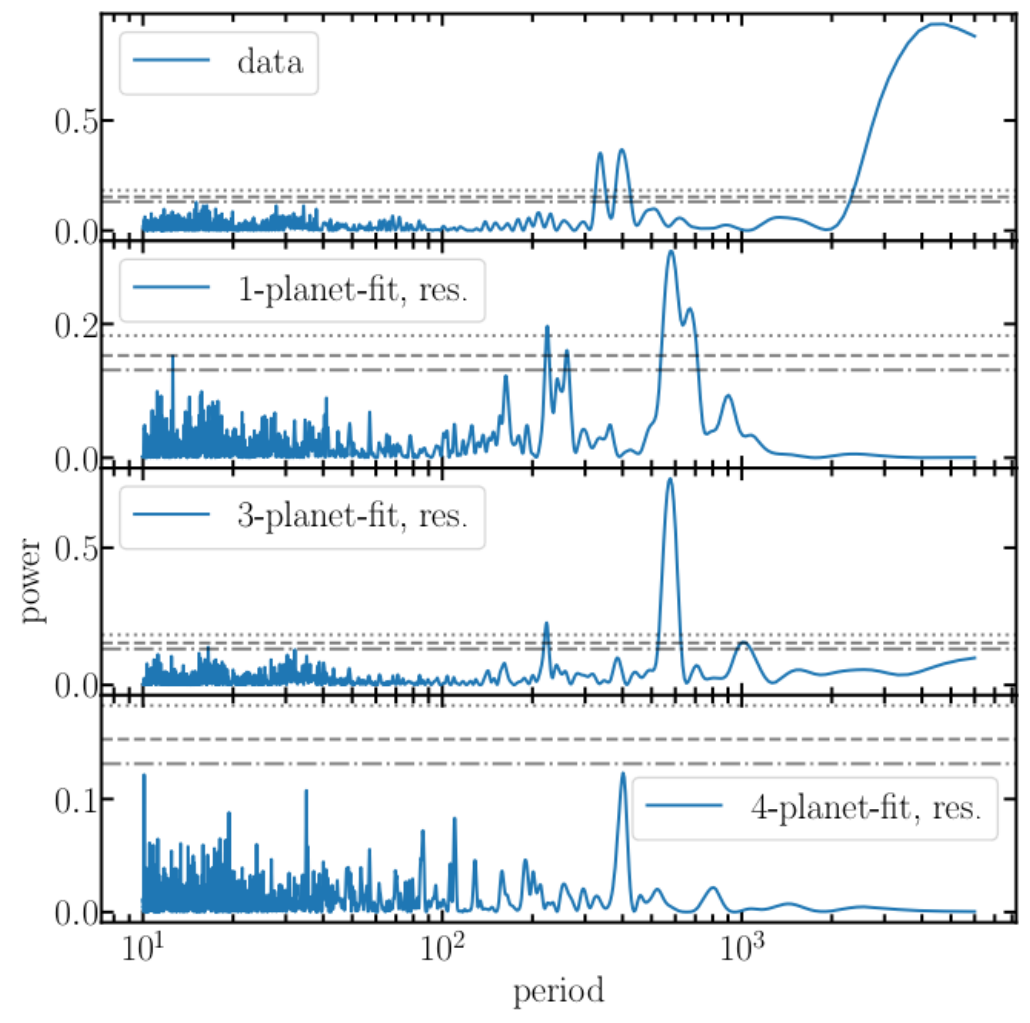

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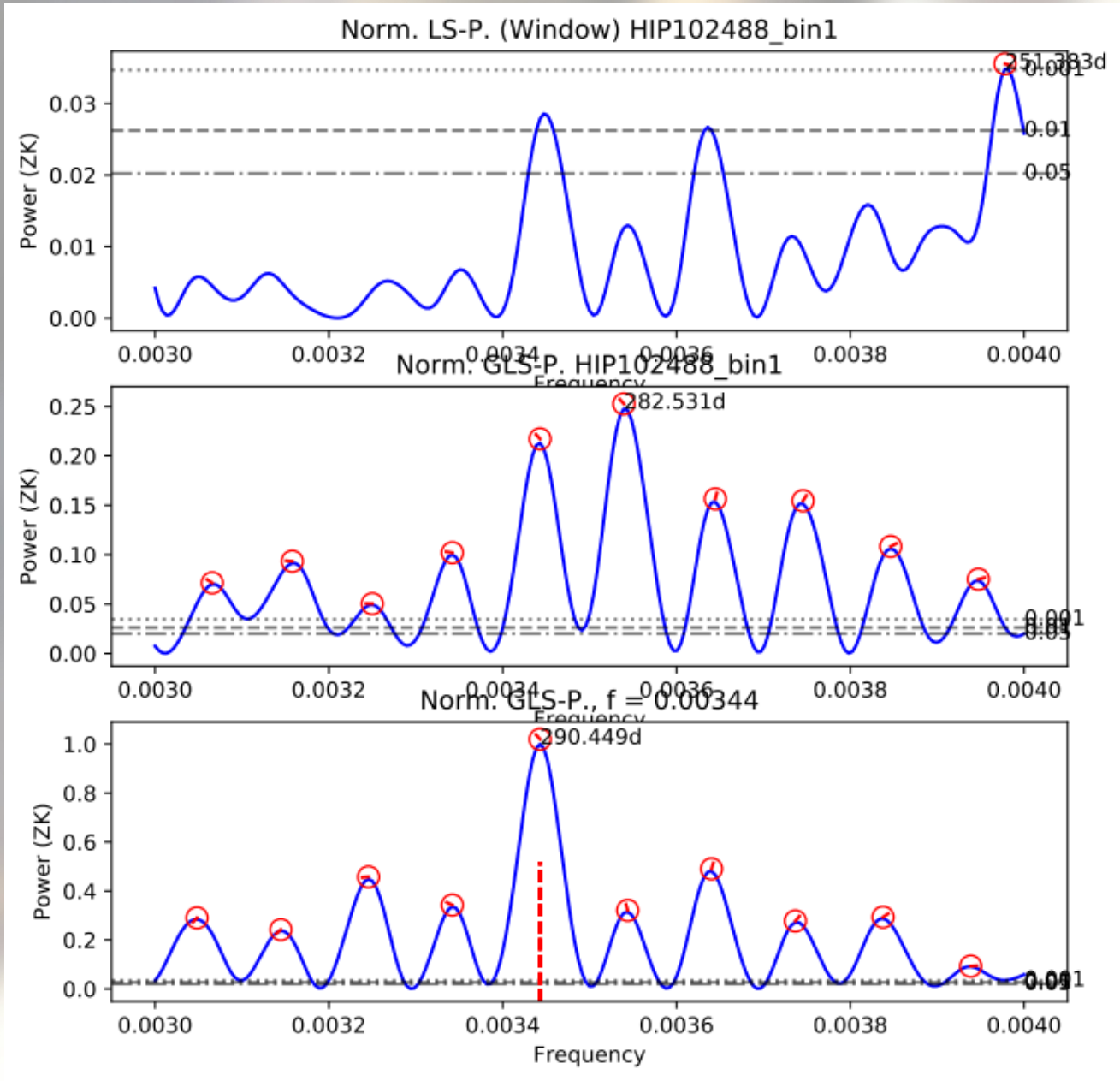

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Both signals most probably are "real"!