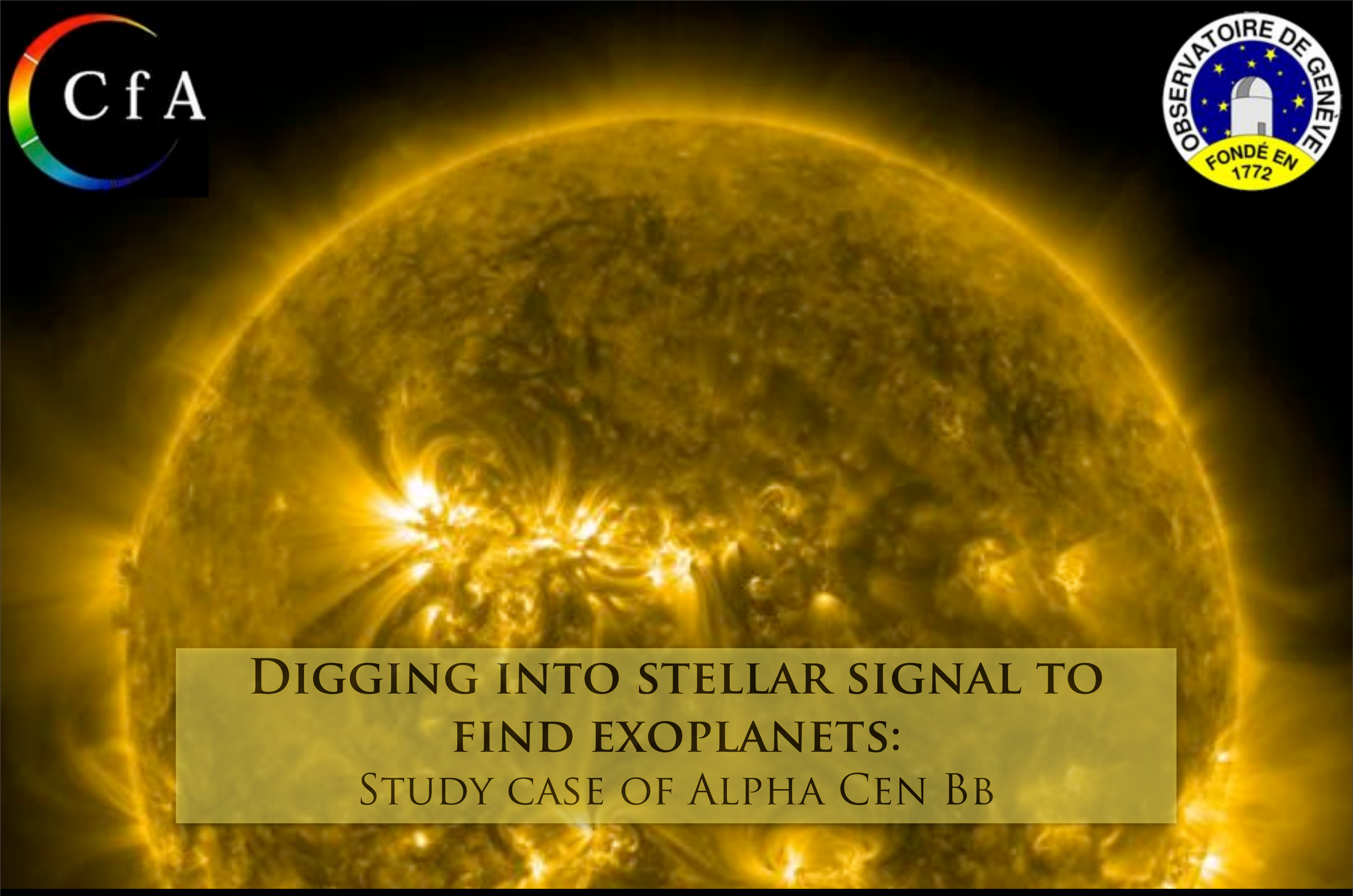


Digging into stellar signal to find exoplanets:
Study case of Alpha Cen Bb

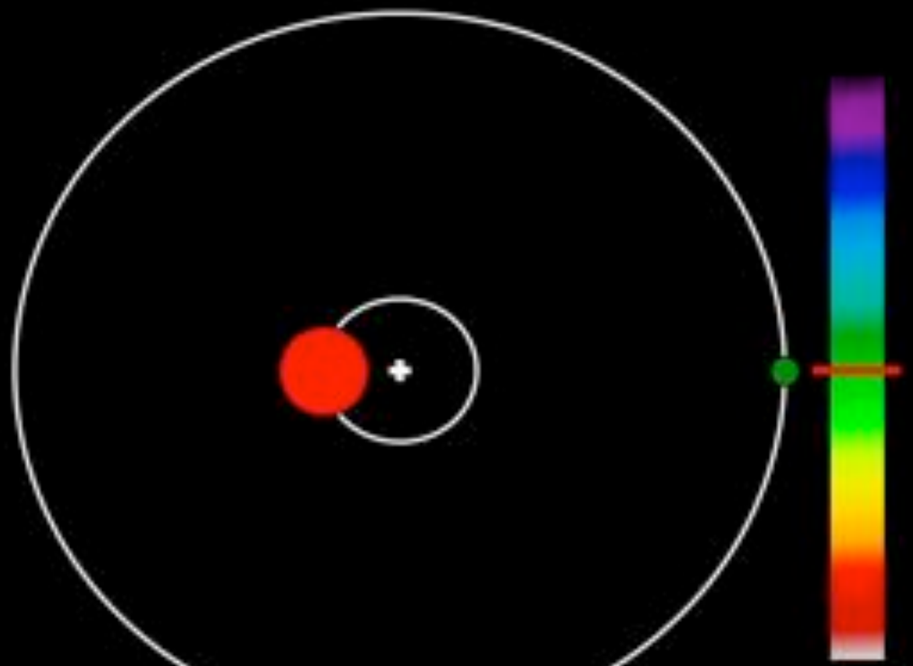
Xavier Dumusque

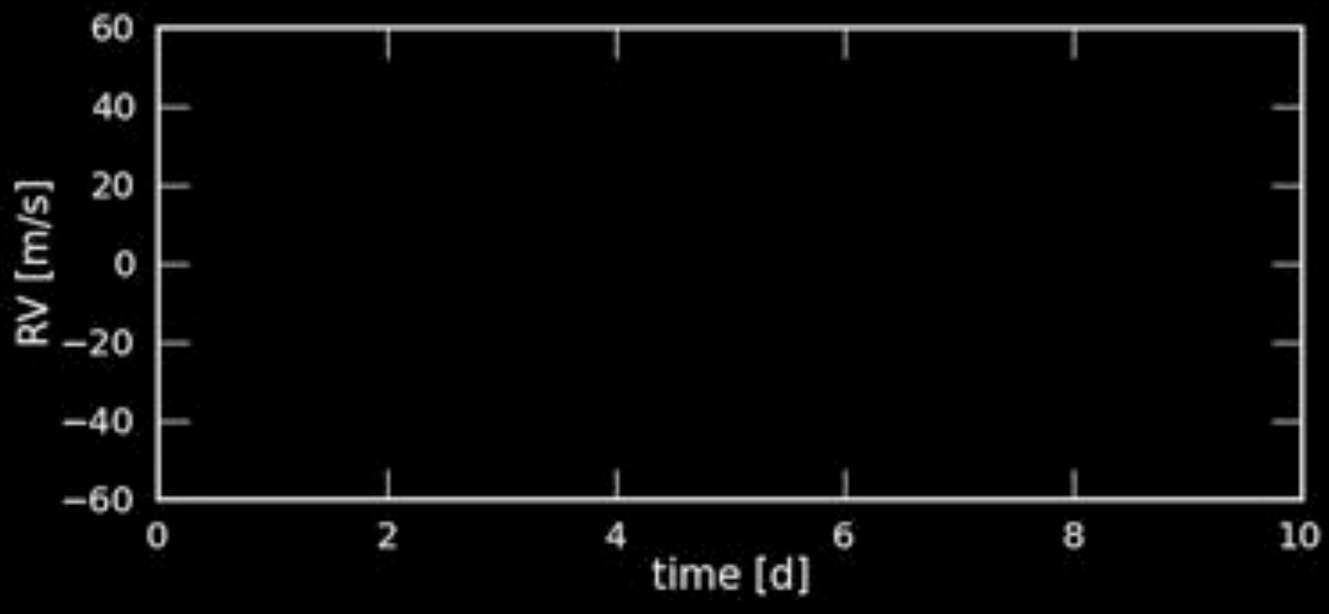
Outline

- The Radial Velocity technique to find exoplanets
- Stellar signals
  - Stellar oscillations
  - Granulation phenomena
  - Rotational activity signal
  - Magnetic cycles
- The Earth-mass planet orbiting Alpha Centauri B
- Conclusions

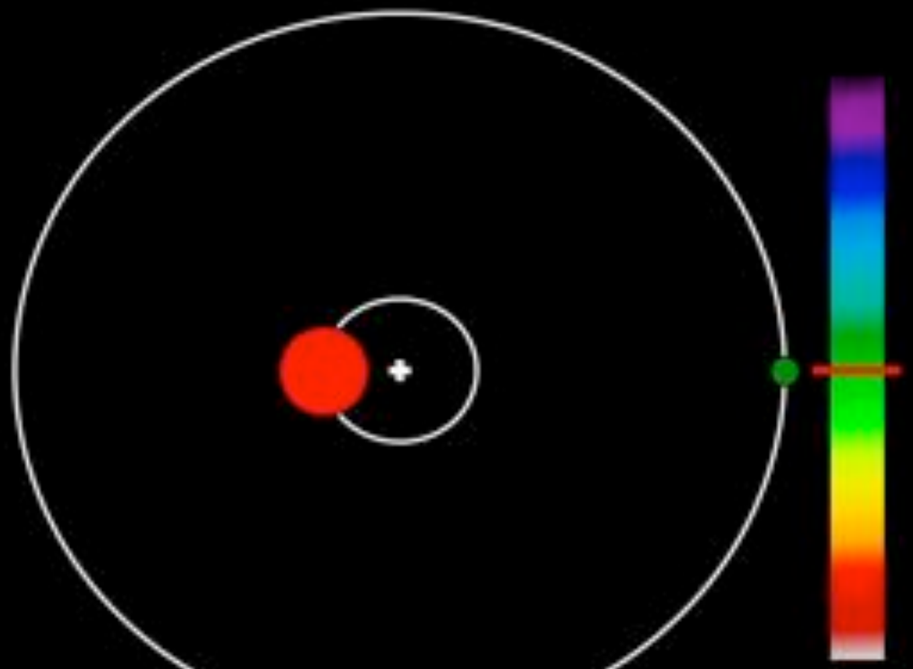
The radial-velocity technique

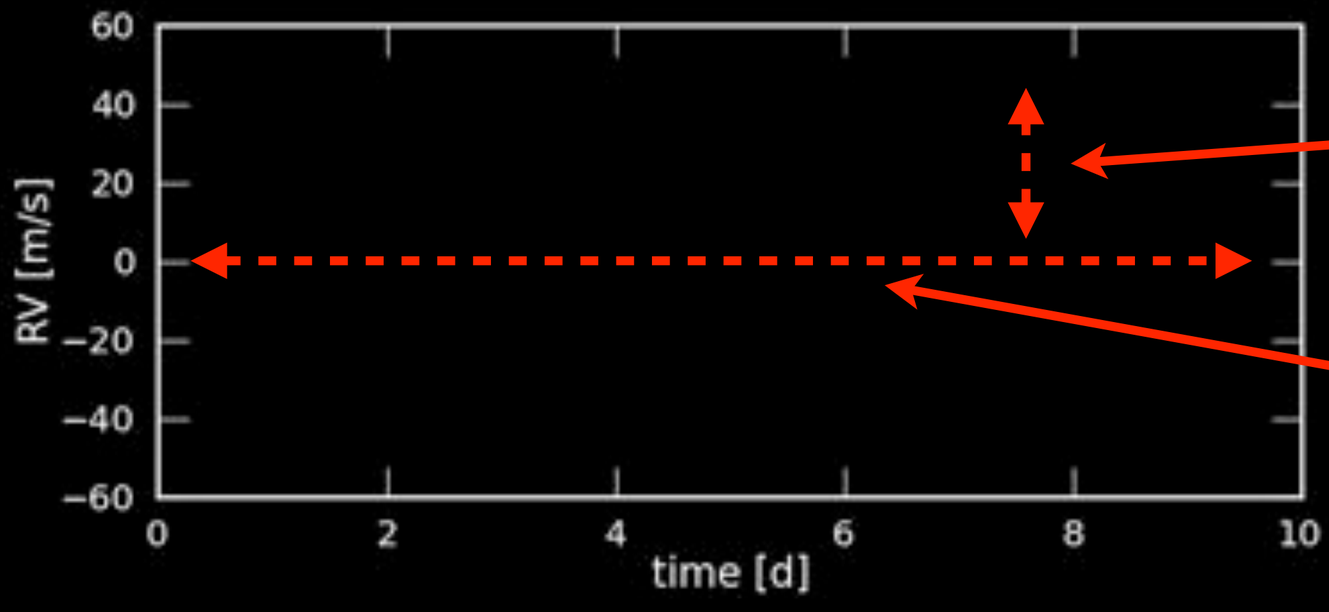
The radial-velocity technique





The radial-velocity technique





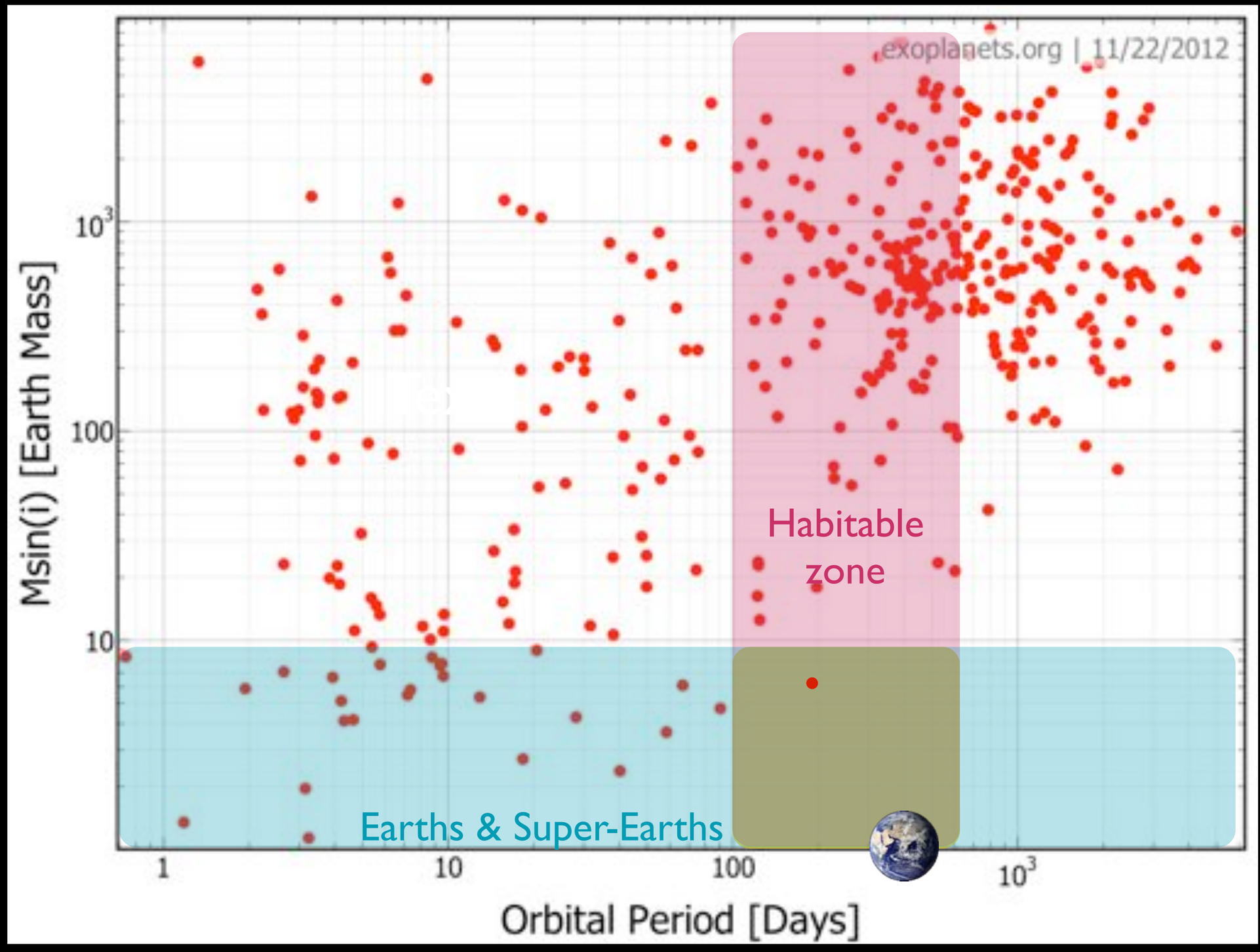
$$\sim \frac{M_{pl} \sin i}{M_\star^{2/3}}$$

$$P_{pl}$$

Exoplanets detected

- Characterization and frequency of small mass planets
- Long period planets
- Bright stars

Atmosphere characterization



Exoplanets detected

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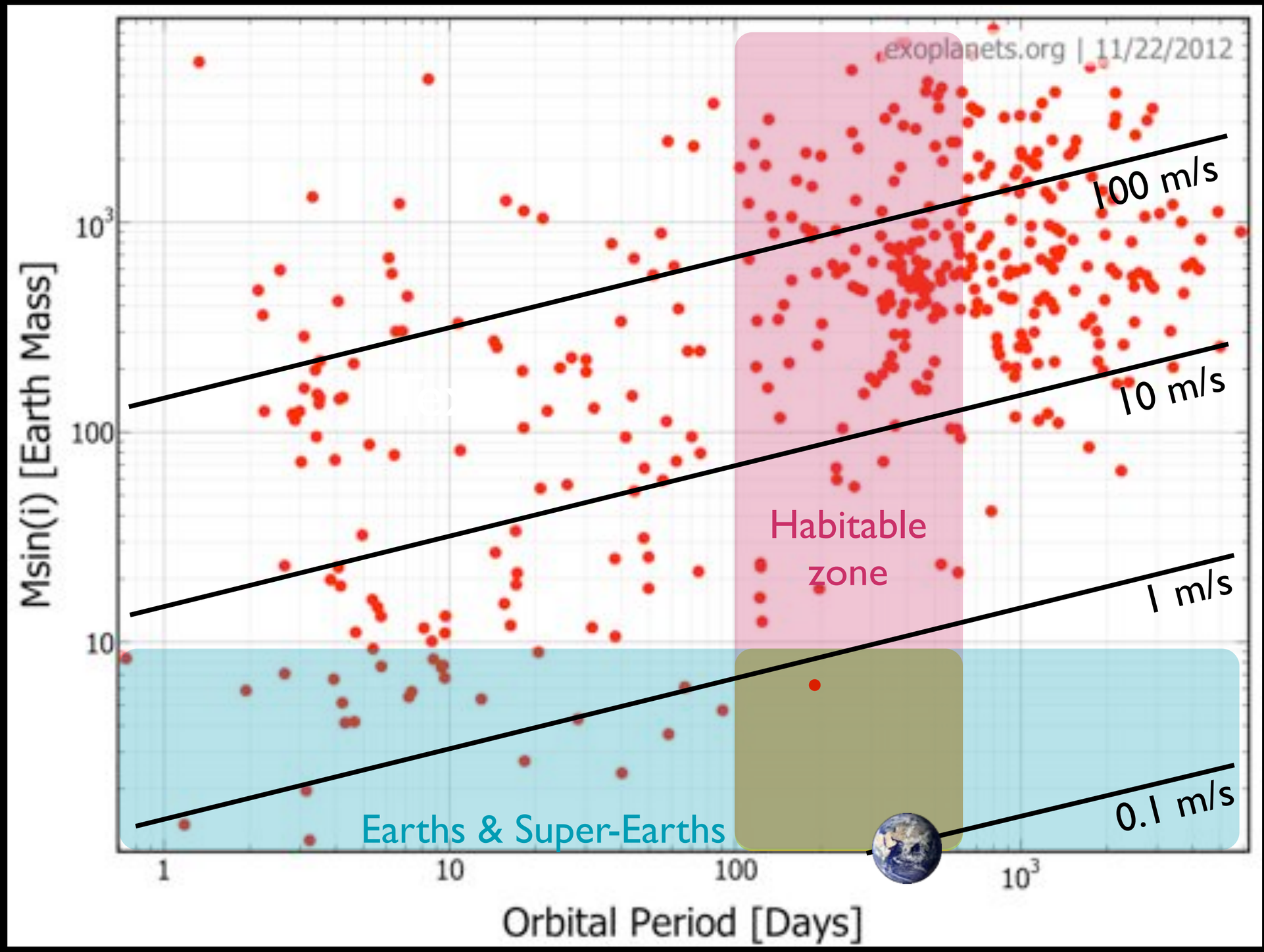
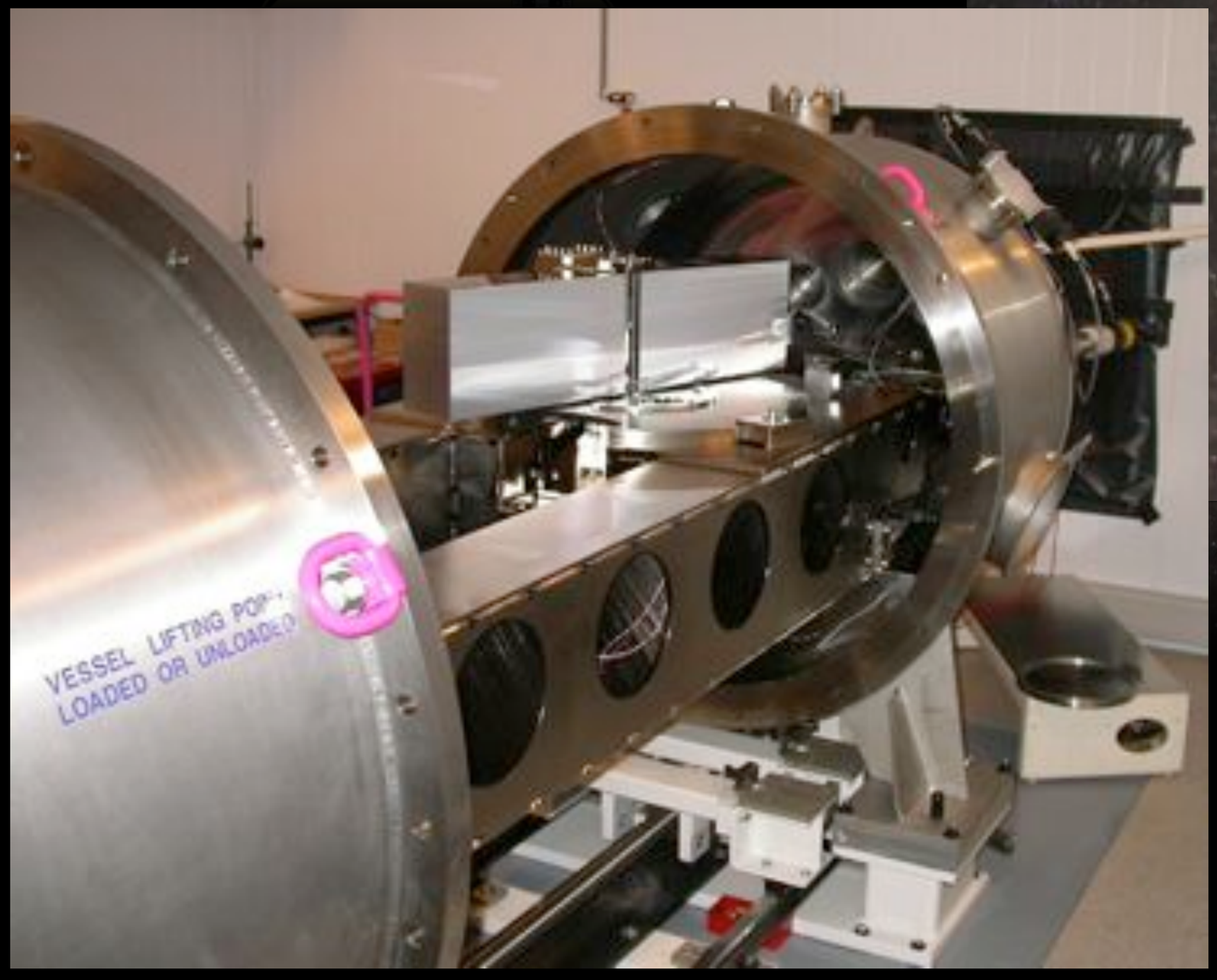
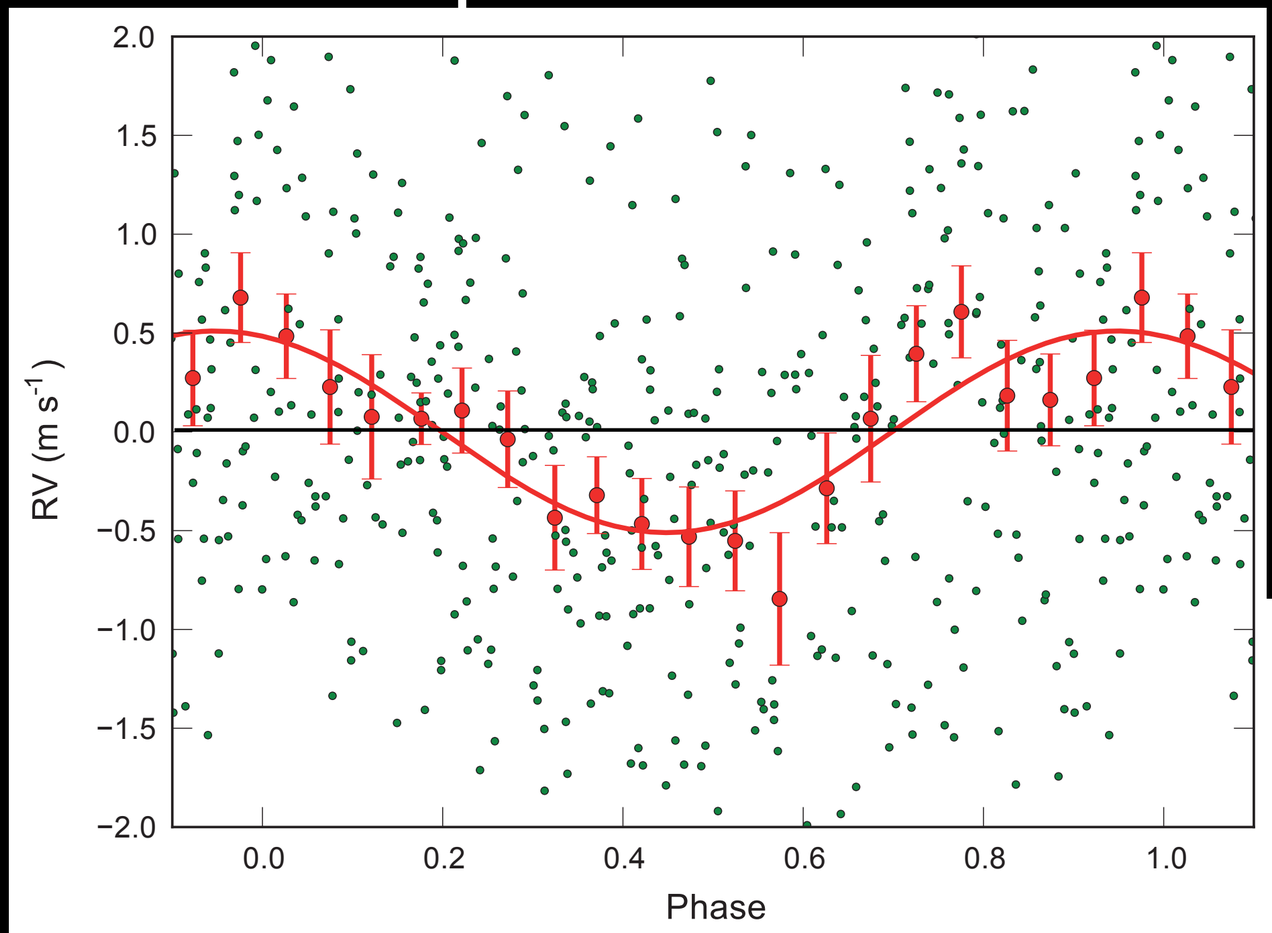


The HARPS spectrograph



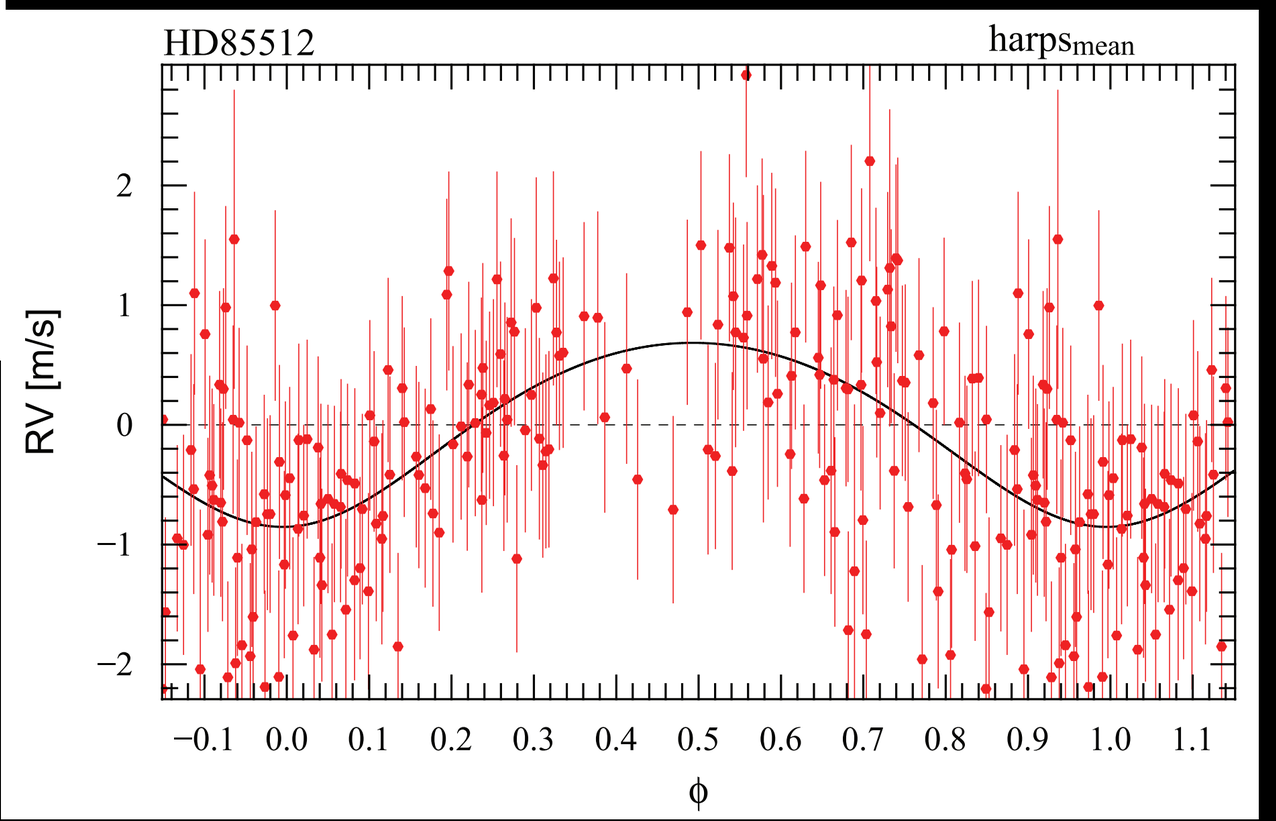
Smallest amplitude planet detected

Alpha Cen B b



0.5 m/s

HD85512 b

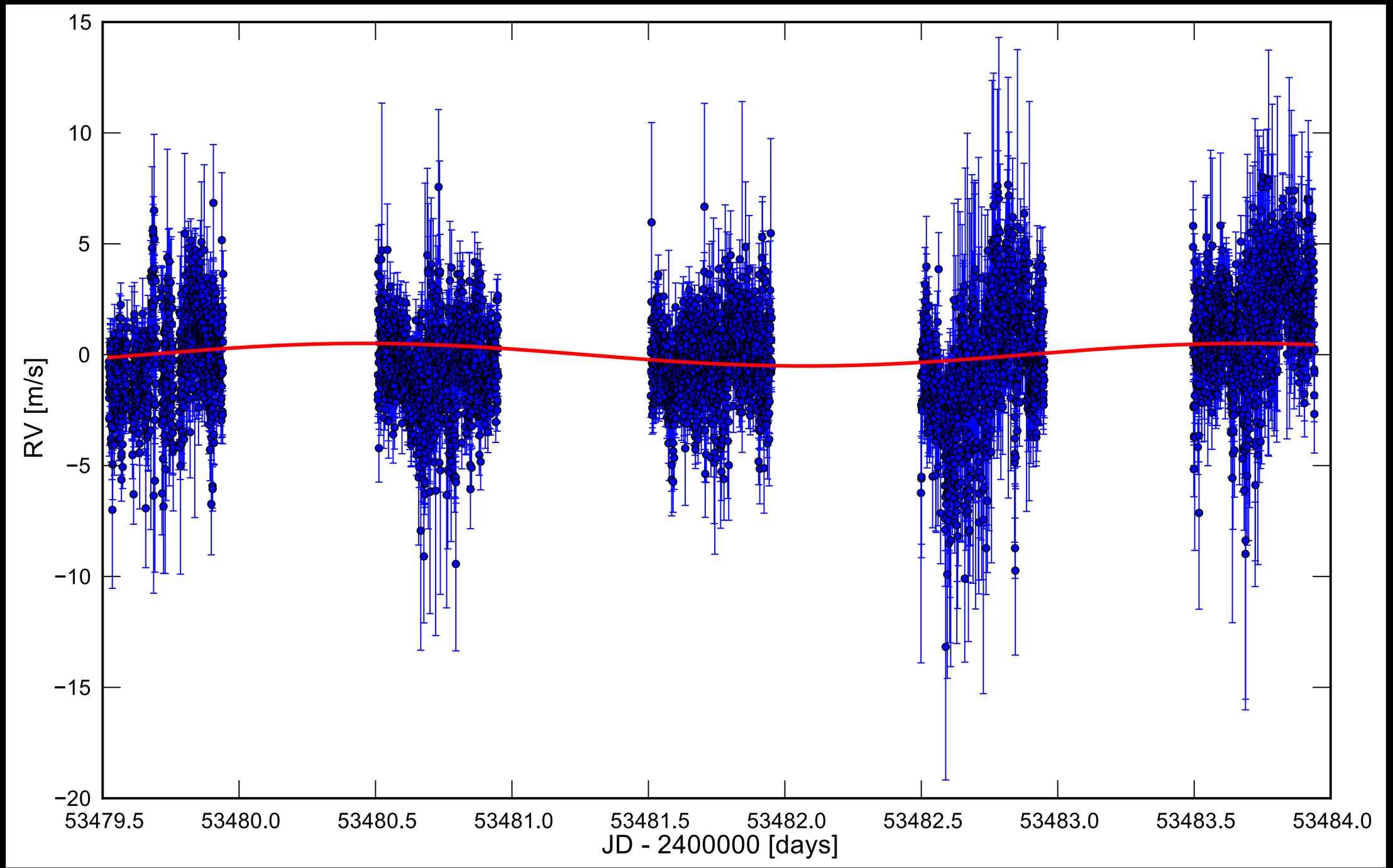


0.8 m/s

Dumusque et al. 2012

Stellar signal variation of a few m/s

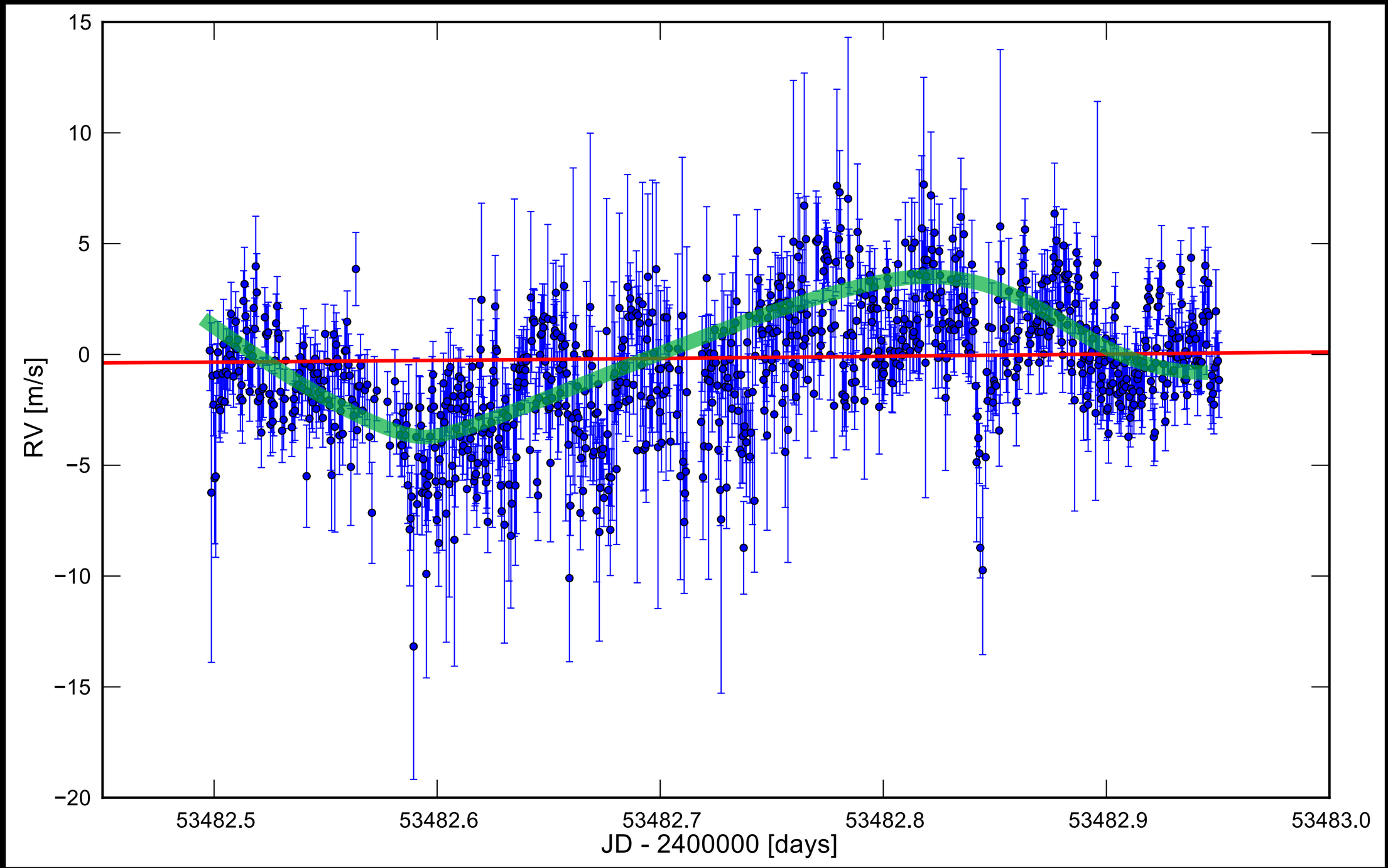
Alpha Cen A



Bazot et al. 2007

Stellar signal variation of a few m/s

Alpha Cen A



Bazot et al. 2007

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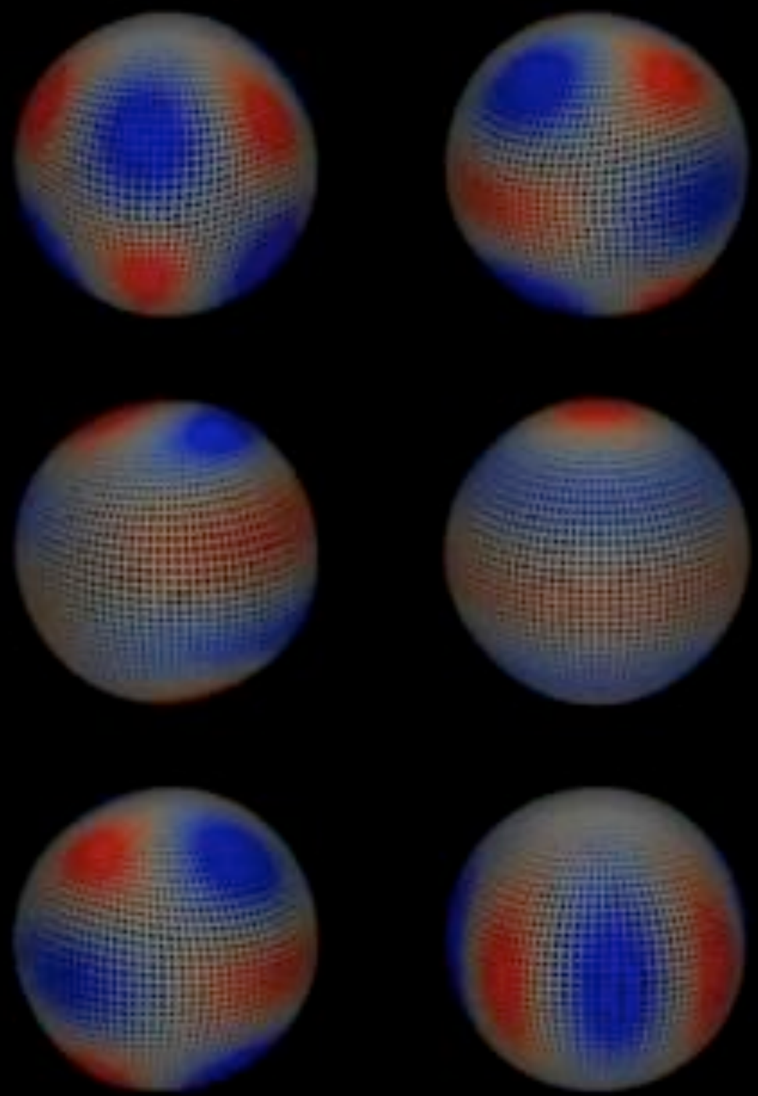
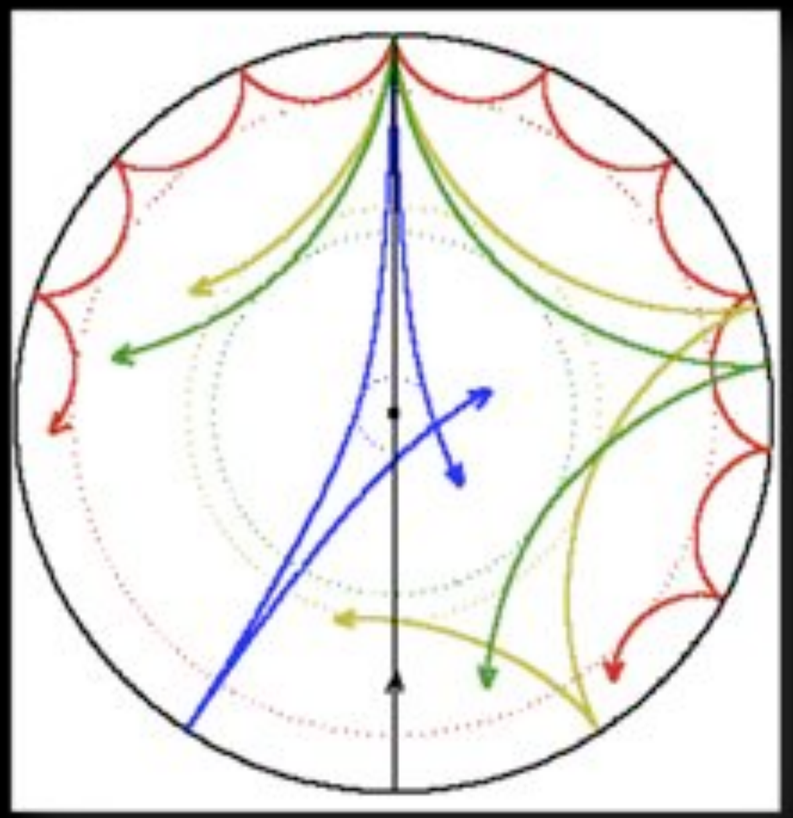
Stellar oscillations

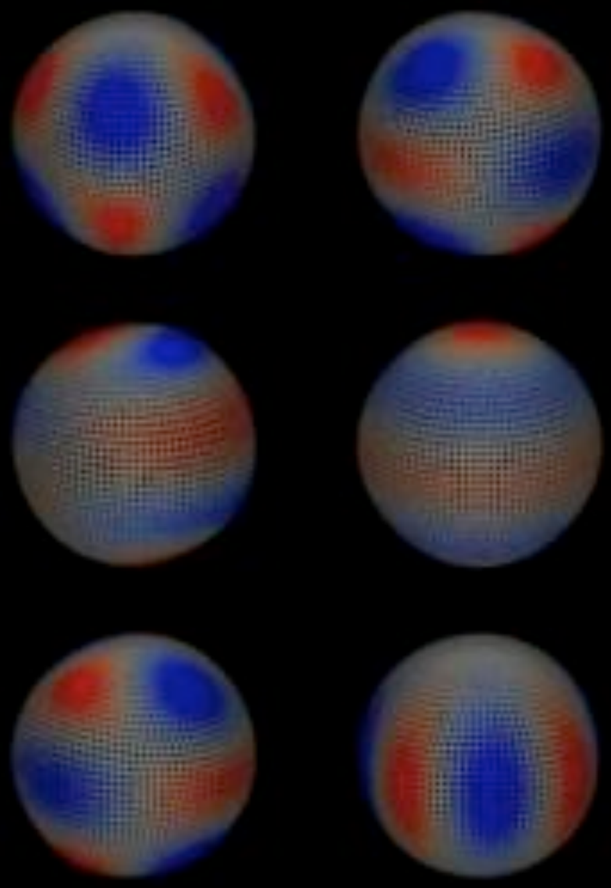


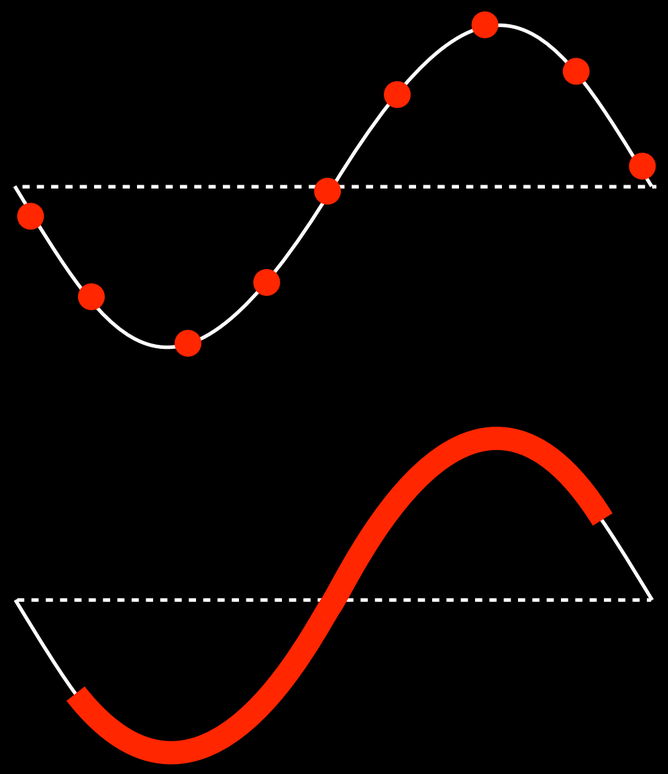


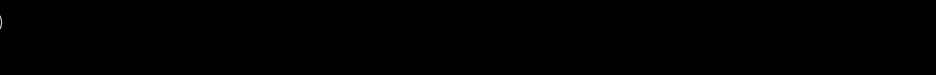
Spectroscopy : 0.1-4 $m.s^{-1}$

Time of oscillations:
3-15 minutes

Mitigate stellar oscillations (p-modes)

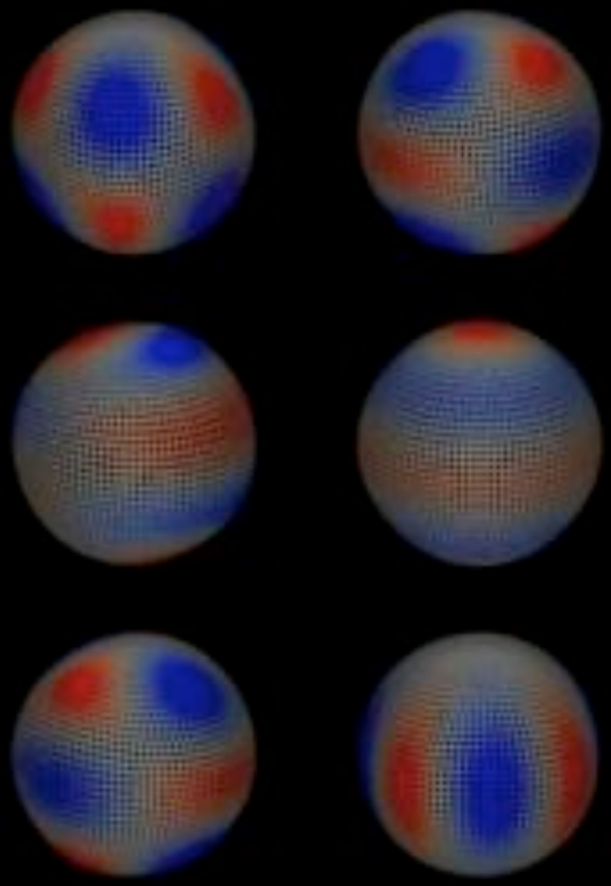


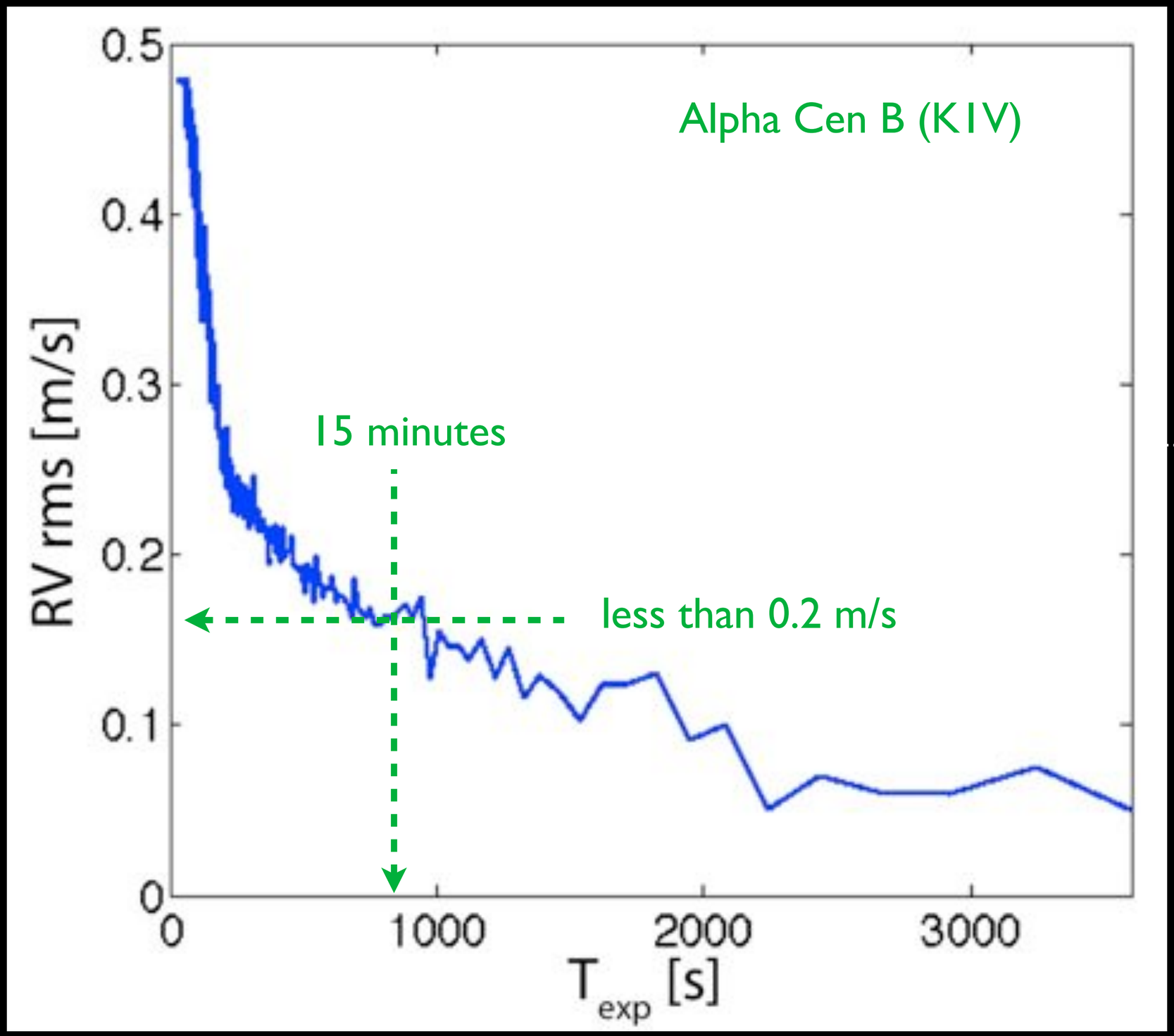




10 minutes

Mitigate stellar oscillations (p-modes)





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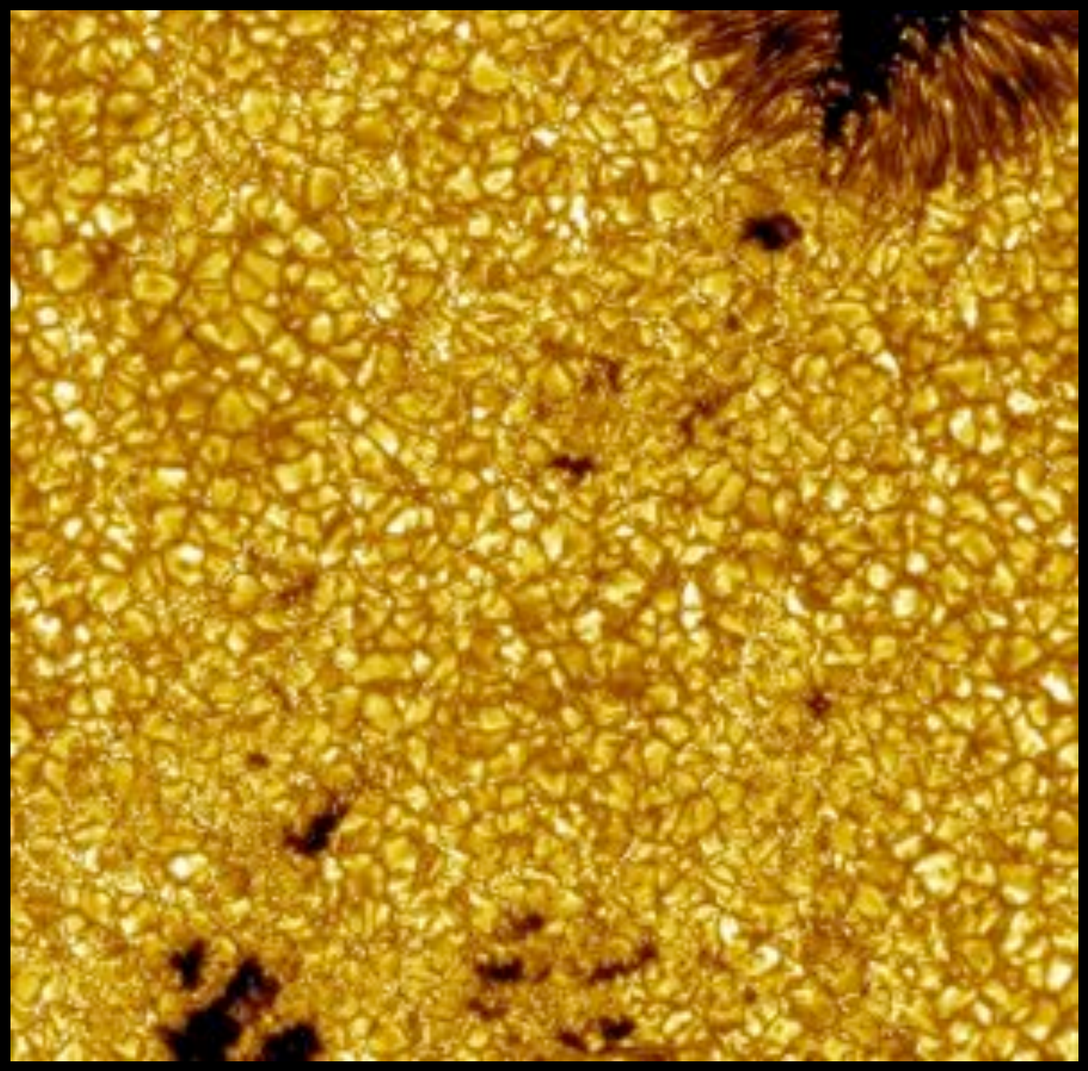
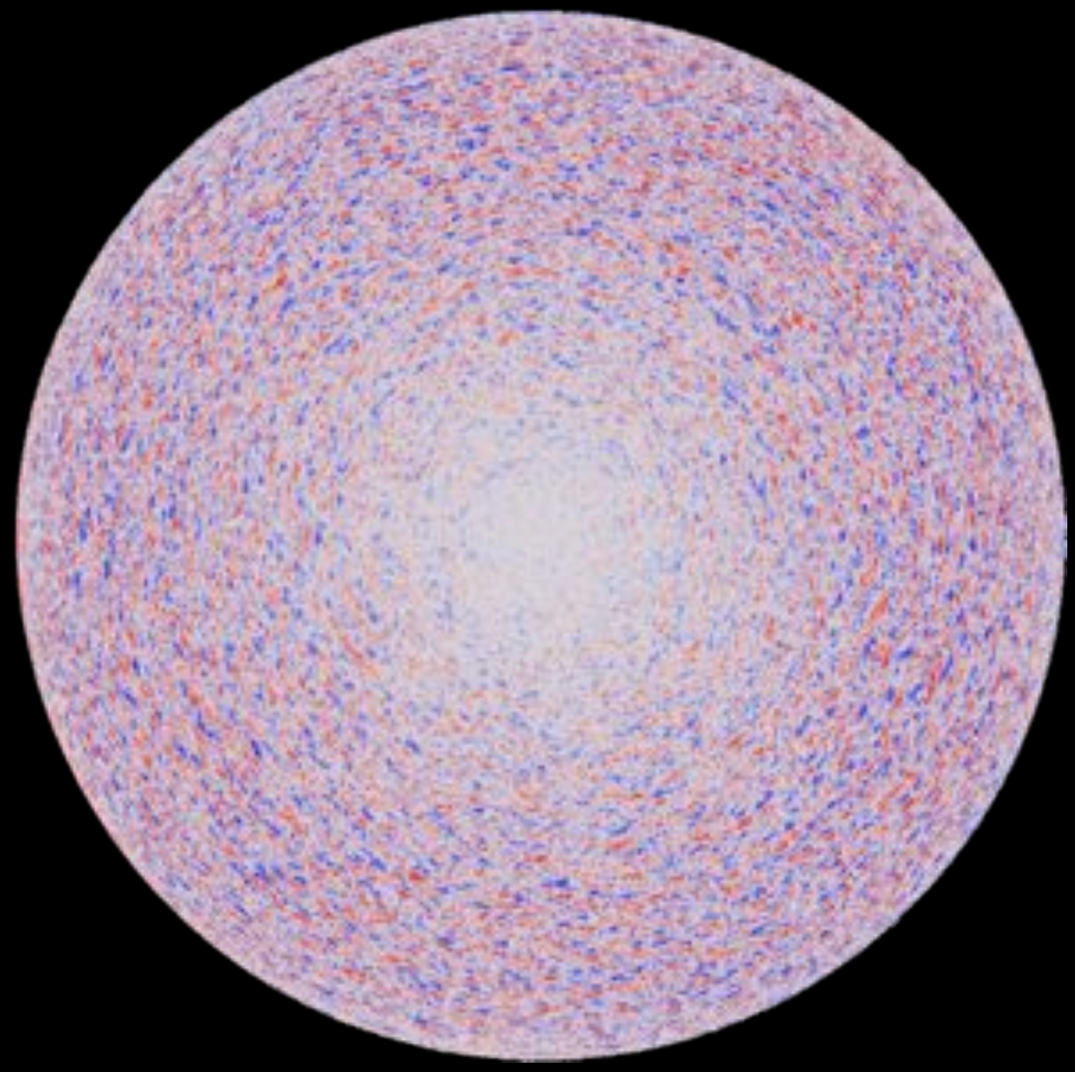
Granulation phenomena

Granulation



300-2000 km - 10^3 $m.s^{-1}$ - > 10 min

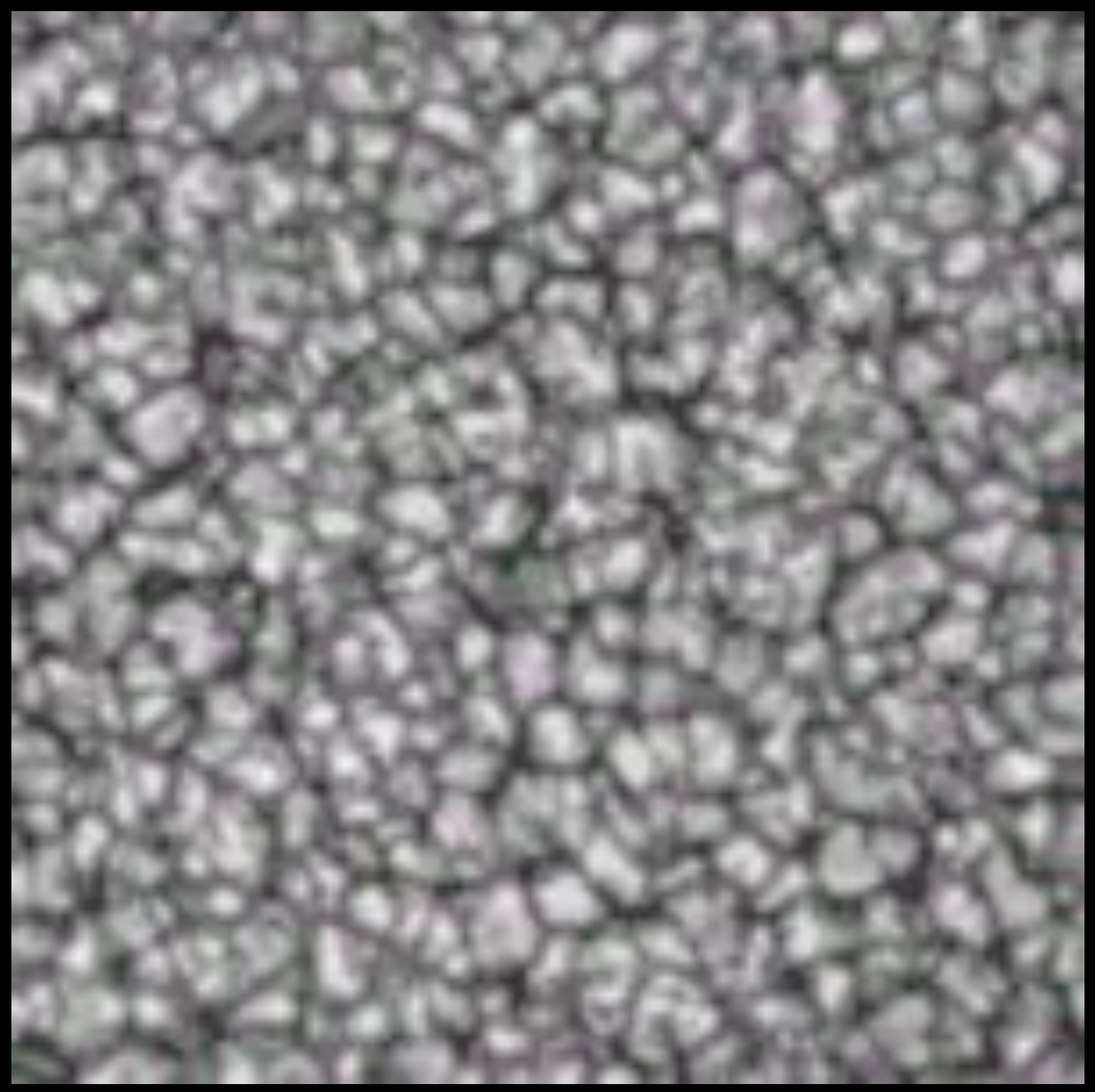
Supergranulation



30 000 km - 10^2 $m.s^{-1}$ - < 2 days

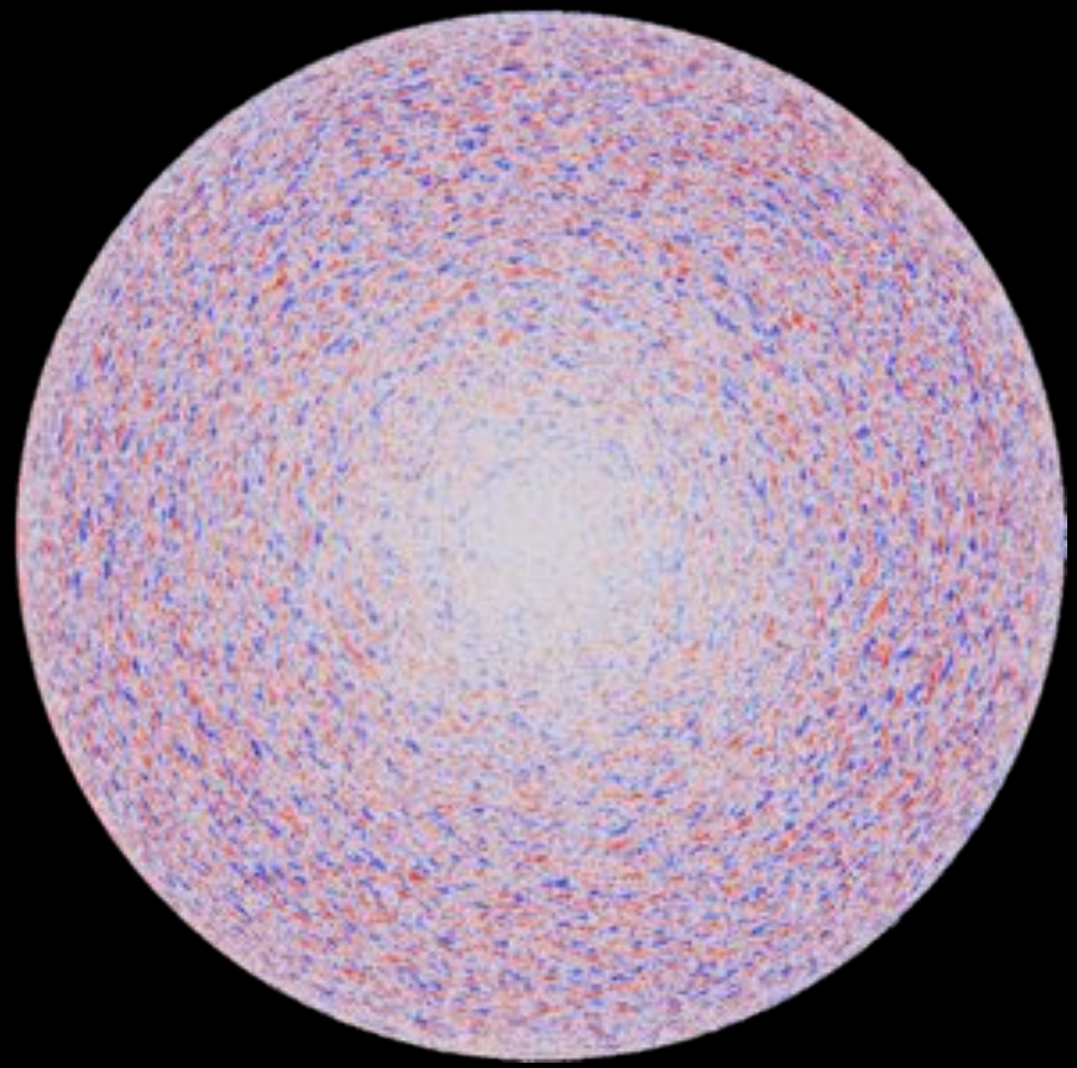
Granulation phenomena

Granulation



300-2000 km - 10^3 $m.s^{-1}$ - > 10 min

Supergranulation

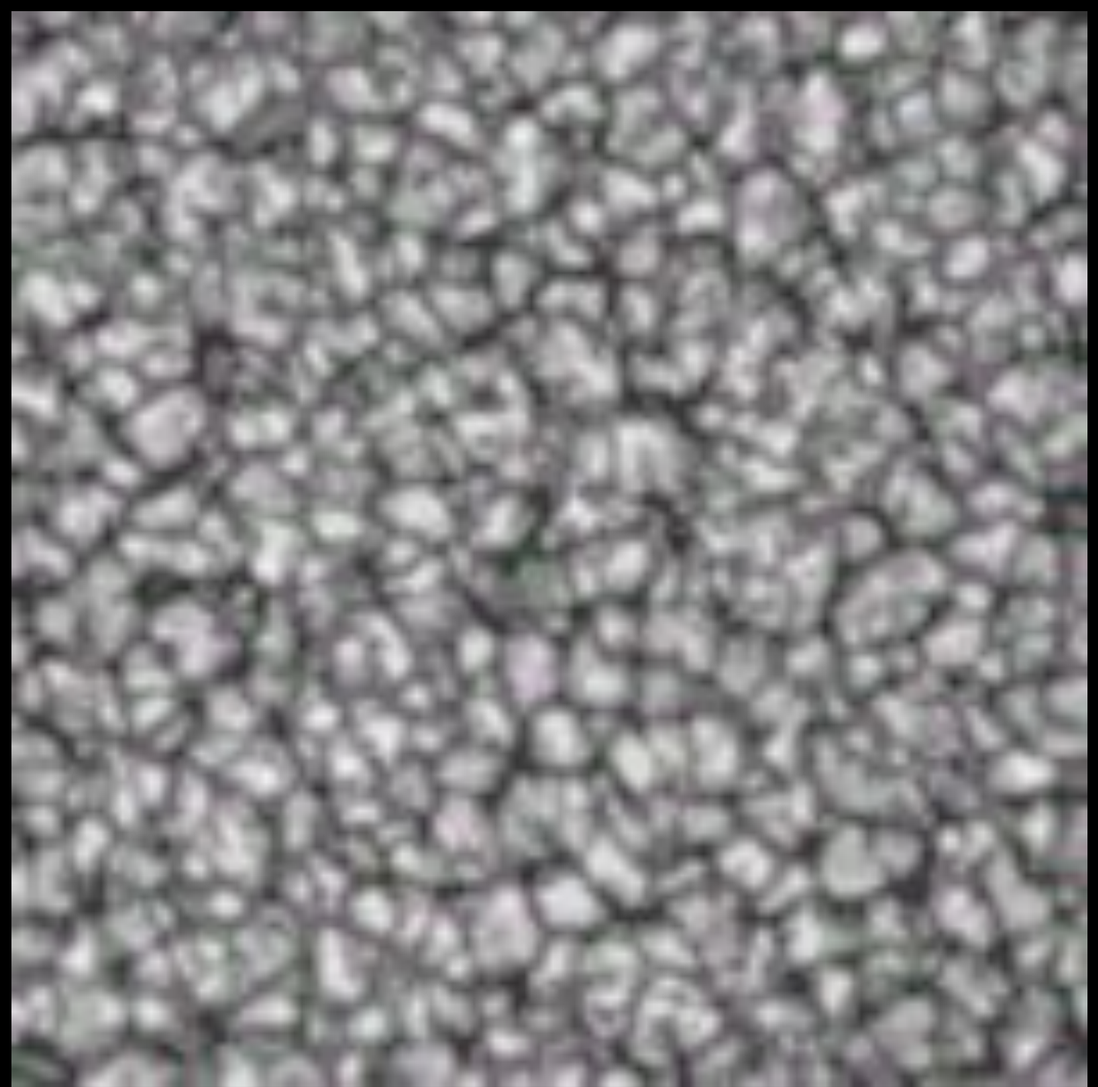


30 000 km - 10^2 $m.s^{-1}$ - < 2 days

Vasco Henriques, MDI/SOHO

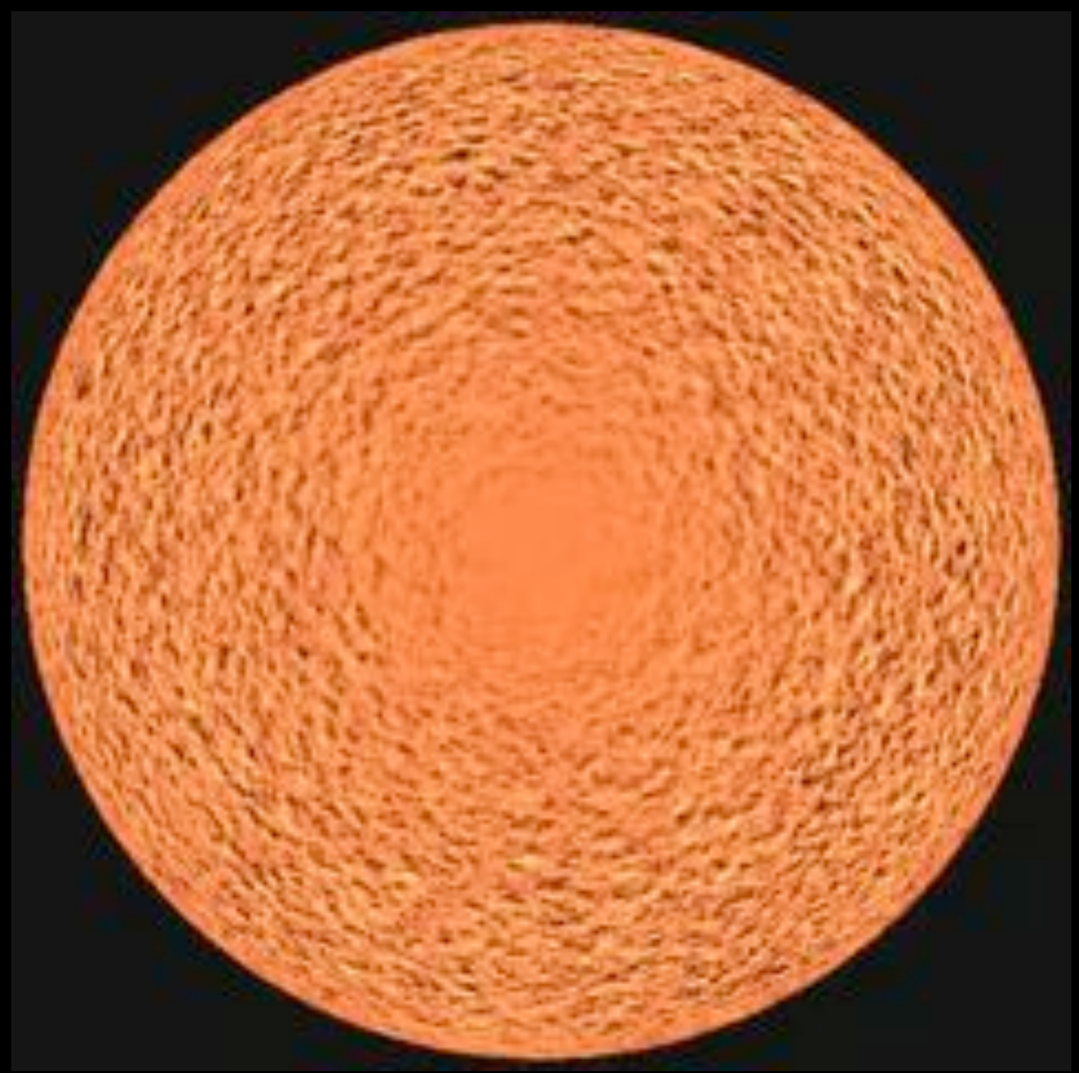
Granulation phenomena

Granulation



300-2000 km - 10^3 $m.s^{-1}$ - > 10 min

Supergranulation

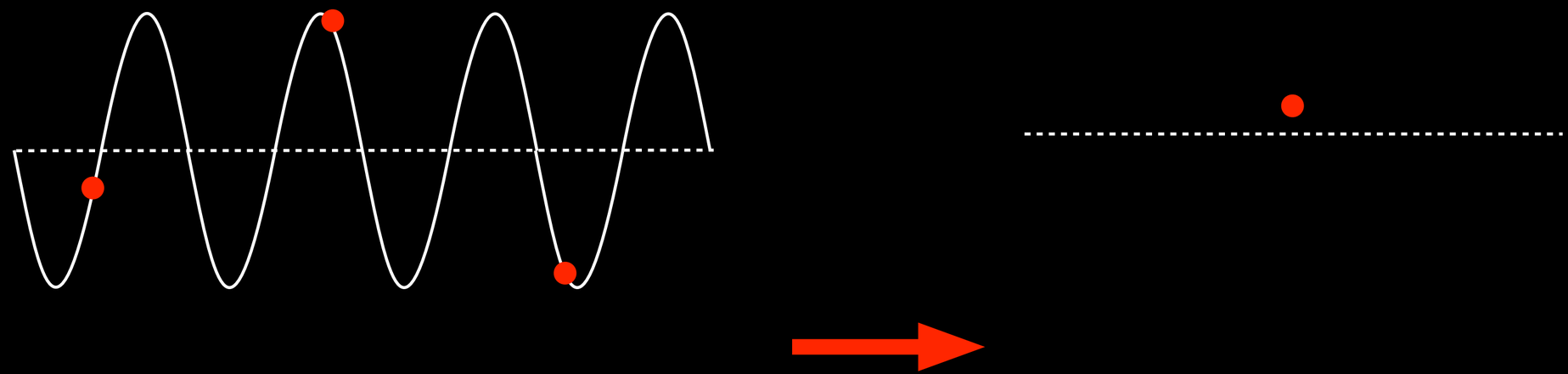


30 000 km - 10^2 $m.s^{-1}$ - < 2 days

Vasco Henriques, MDI/SOHO

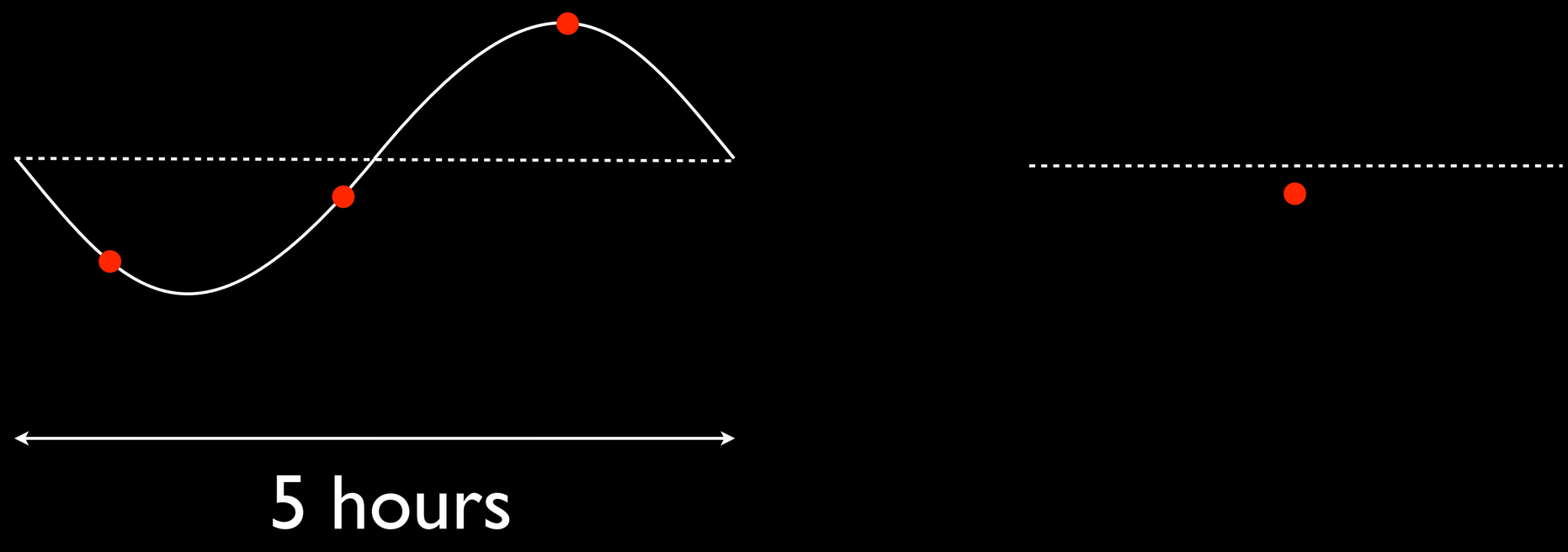
Mitigate granulation phenomena

Granulation



average

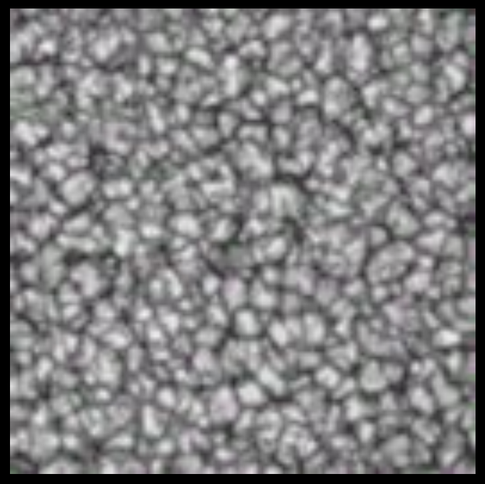
Supergranulation

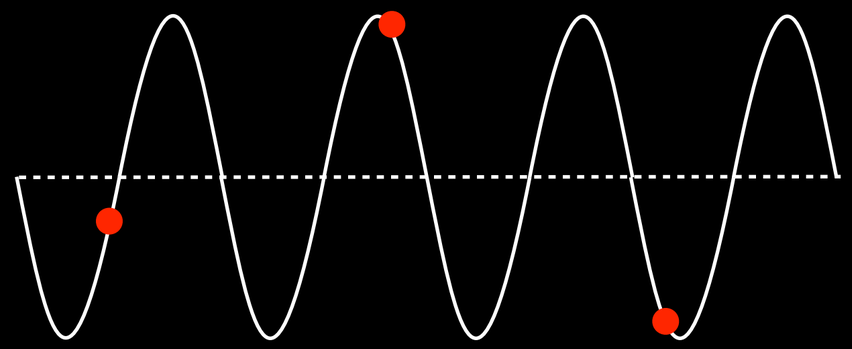


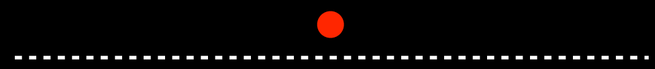
5 hours

Mitigate granulation phenomena

Granulation

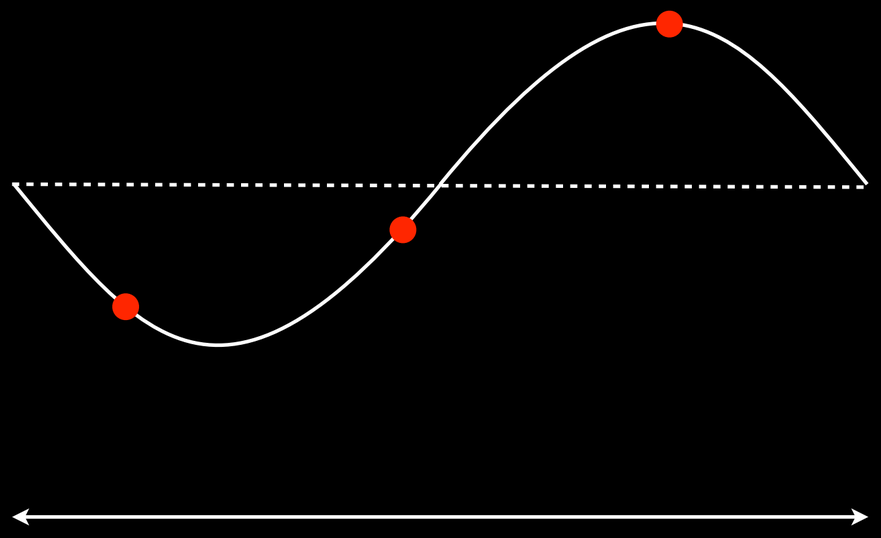


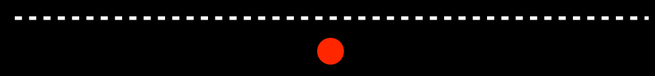




average

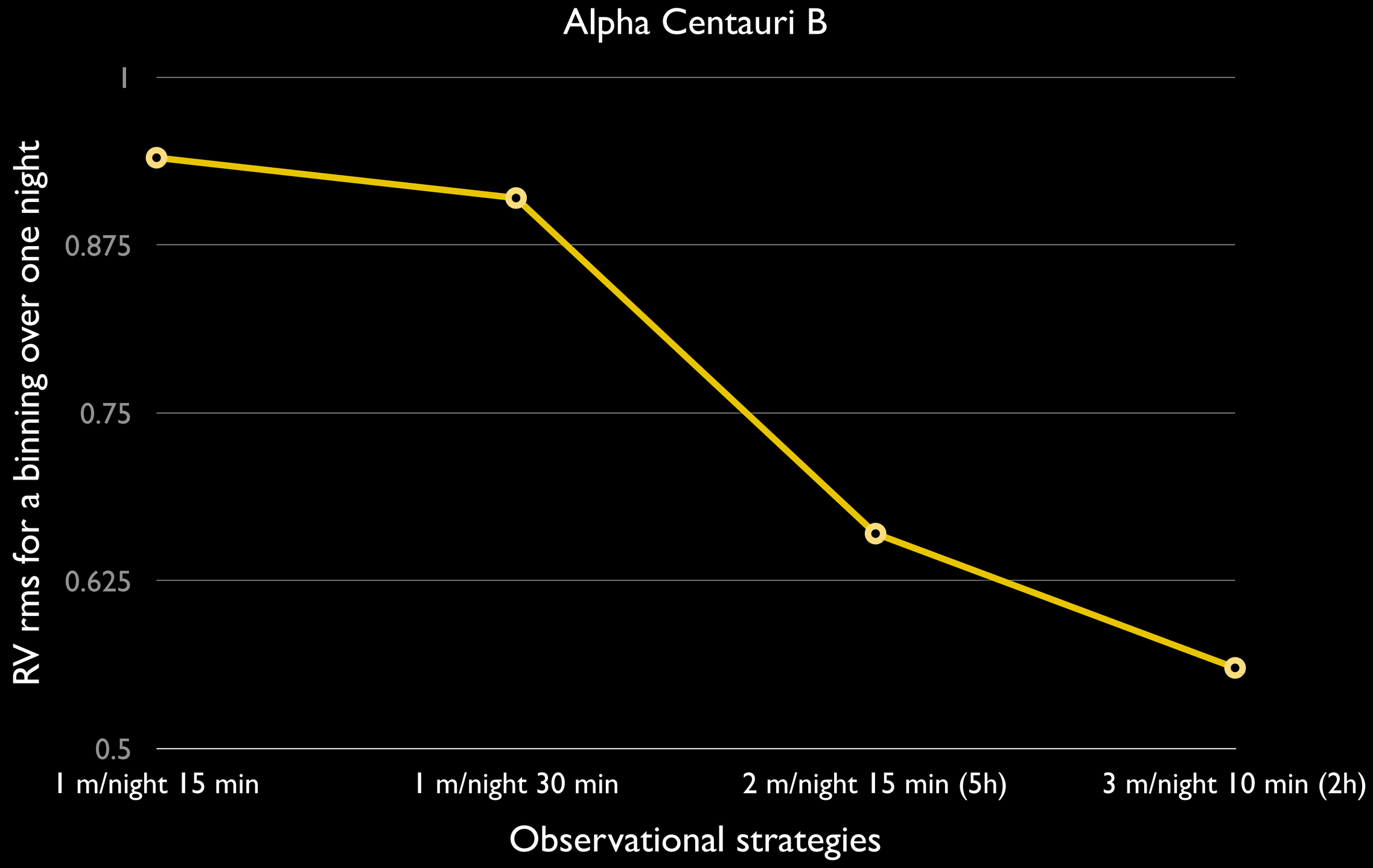
Supergranulation





5 hours

Observational strategy



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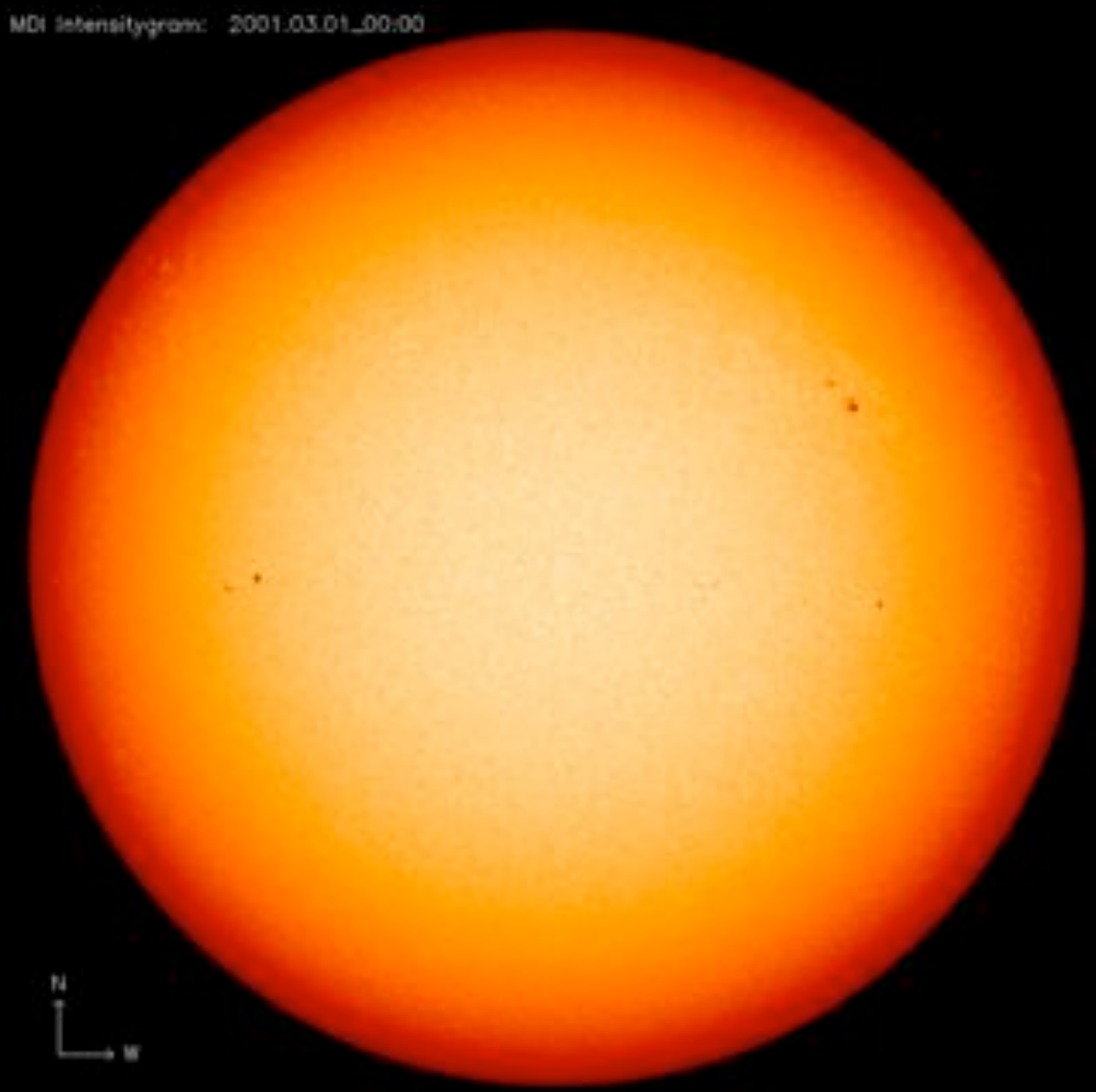
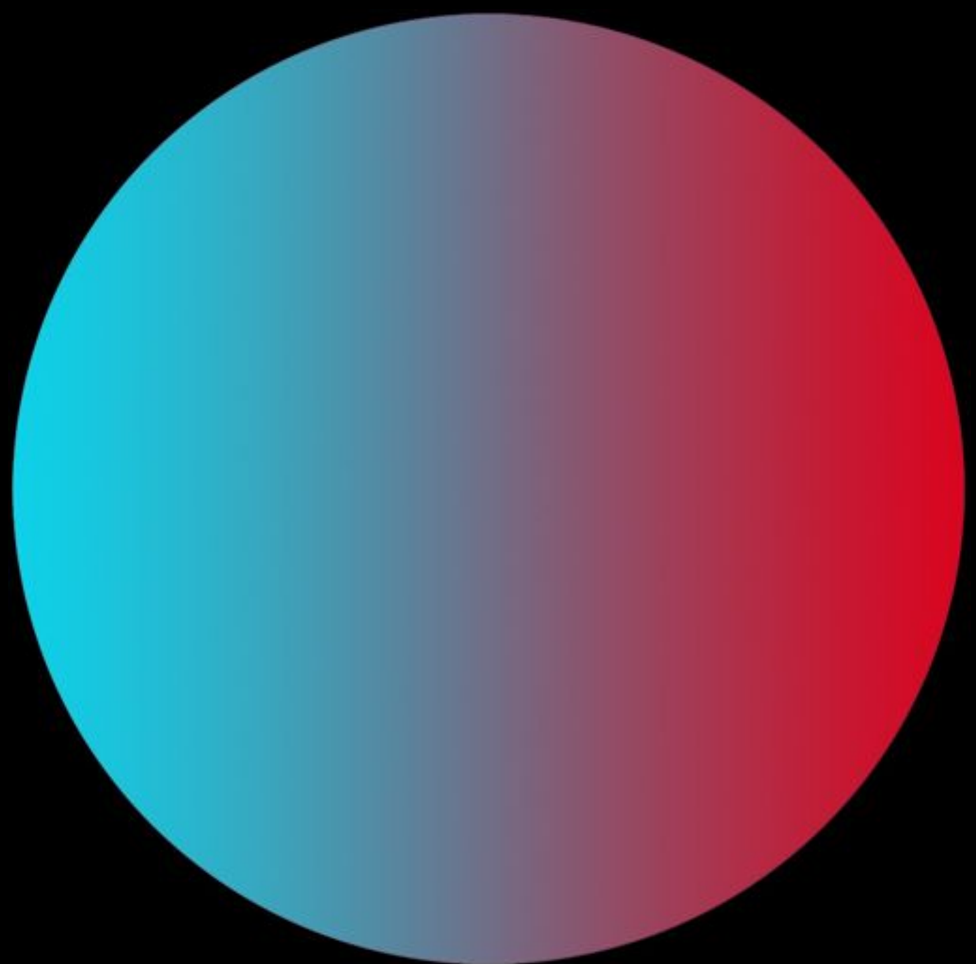
Rotational activity



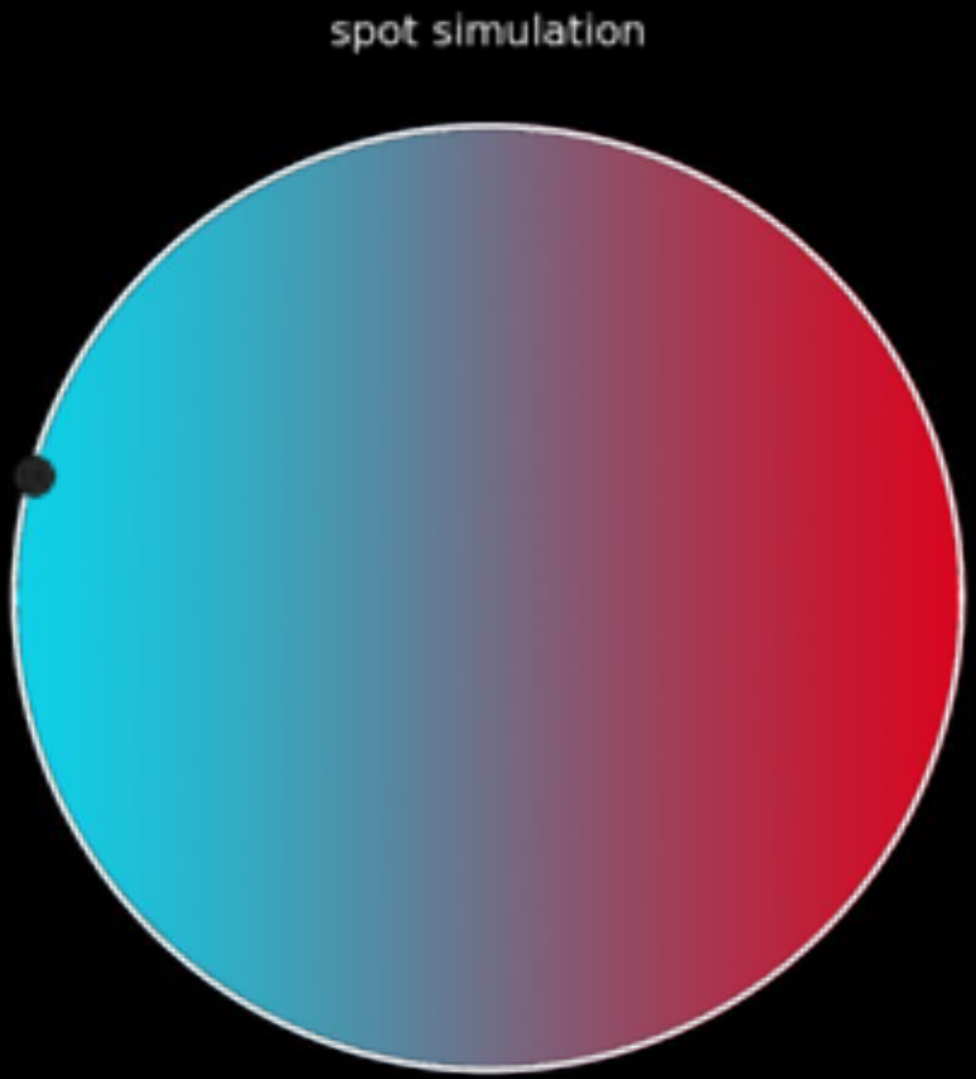
SOHO

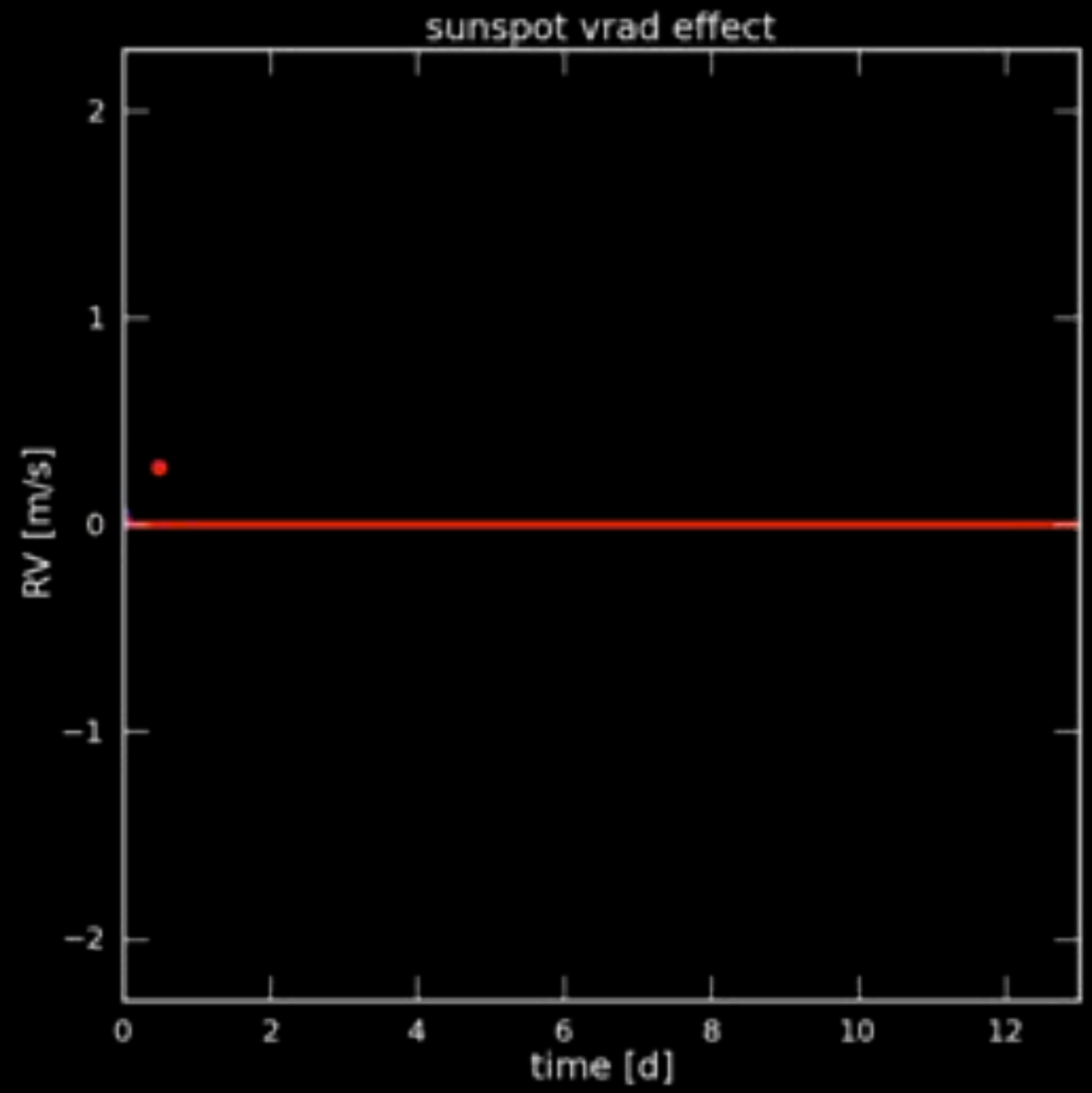
Sunspot effect in RV



SOAP simulation, Boisse et al. 2012

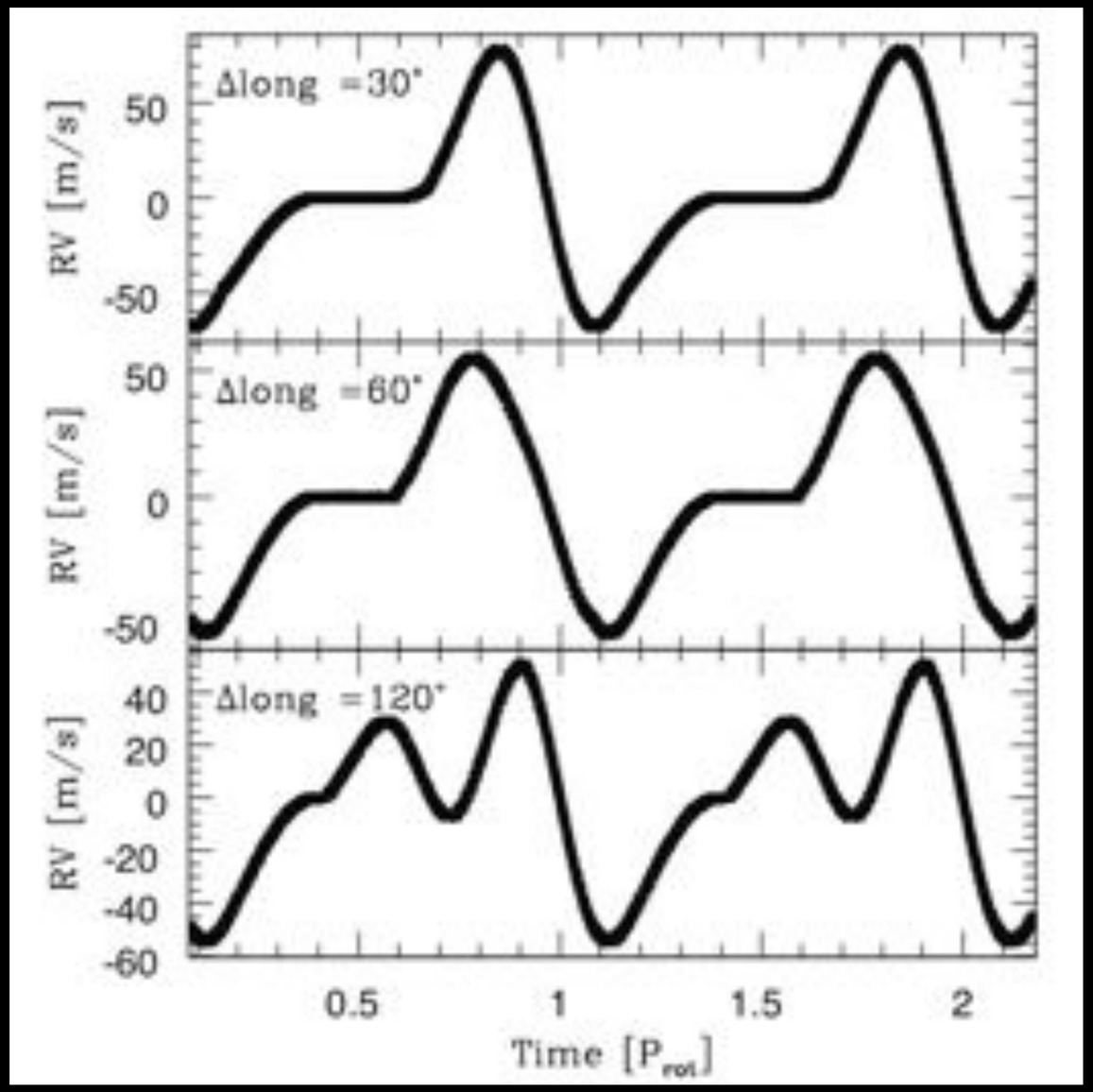
Sunspot effect in RV

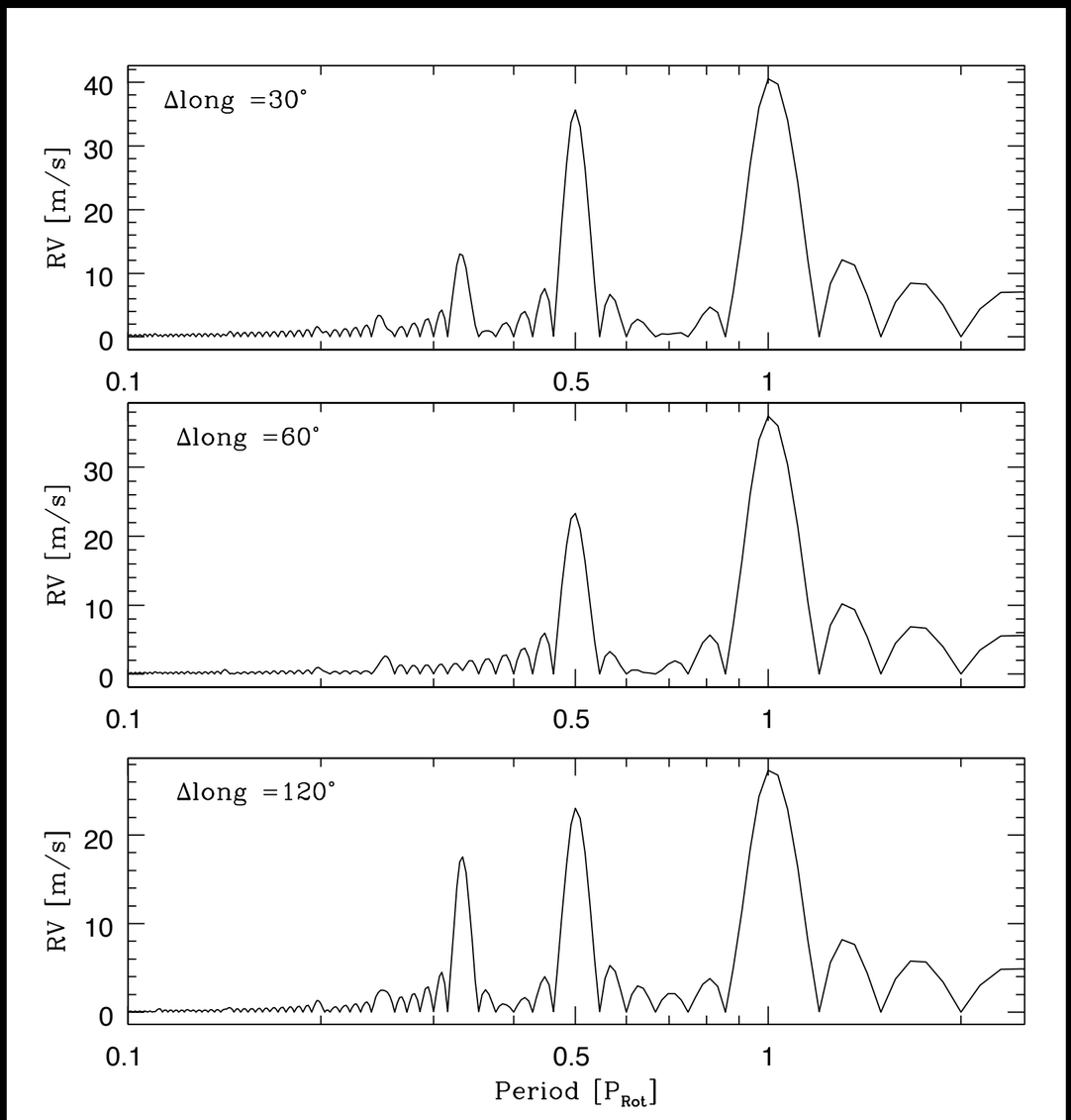




SOAP simulation, Boisse et al. 2012

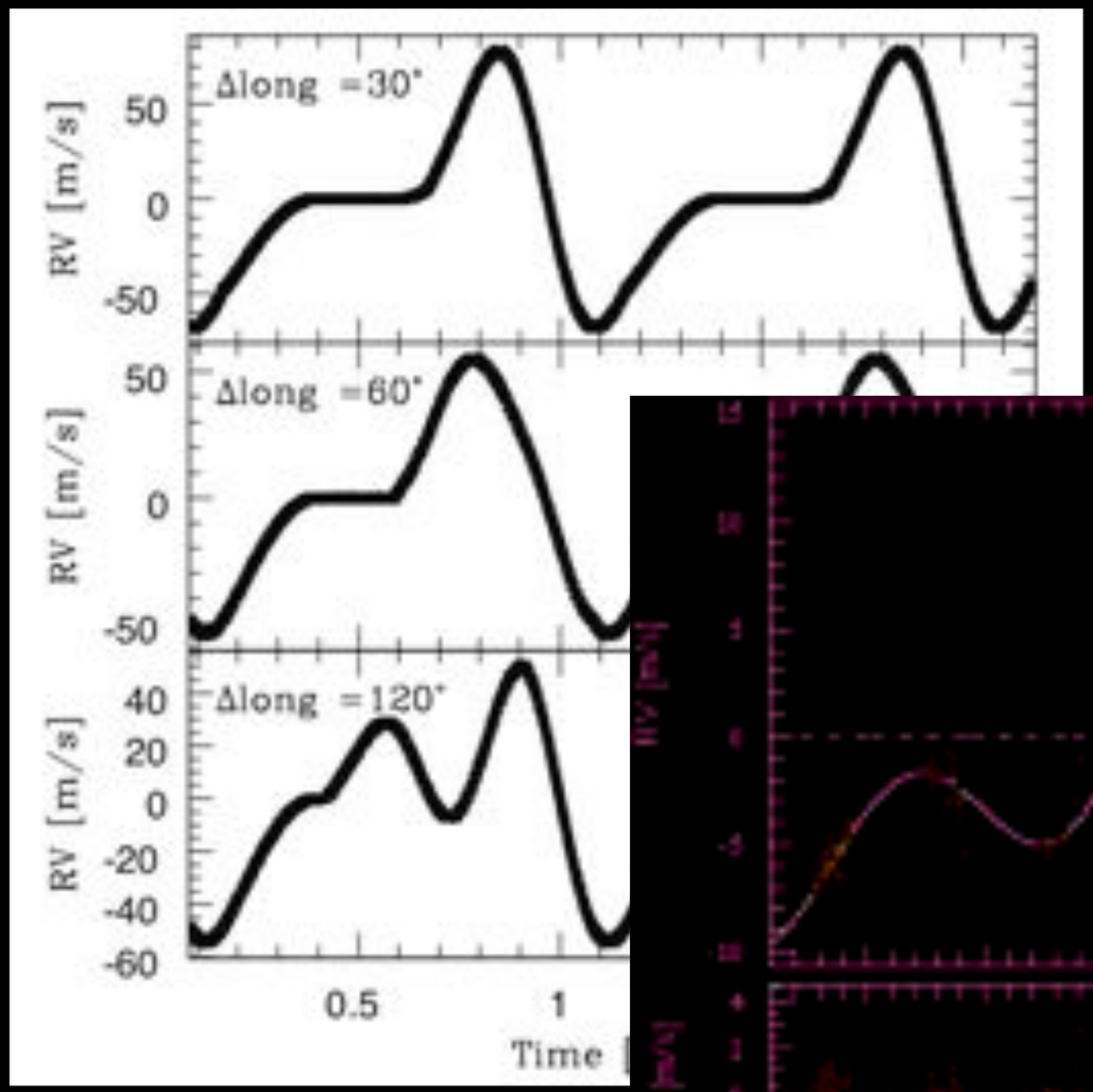
Fitting sine waves to reduced rotational activity

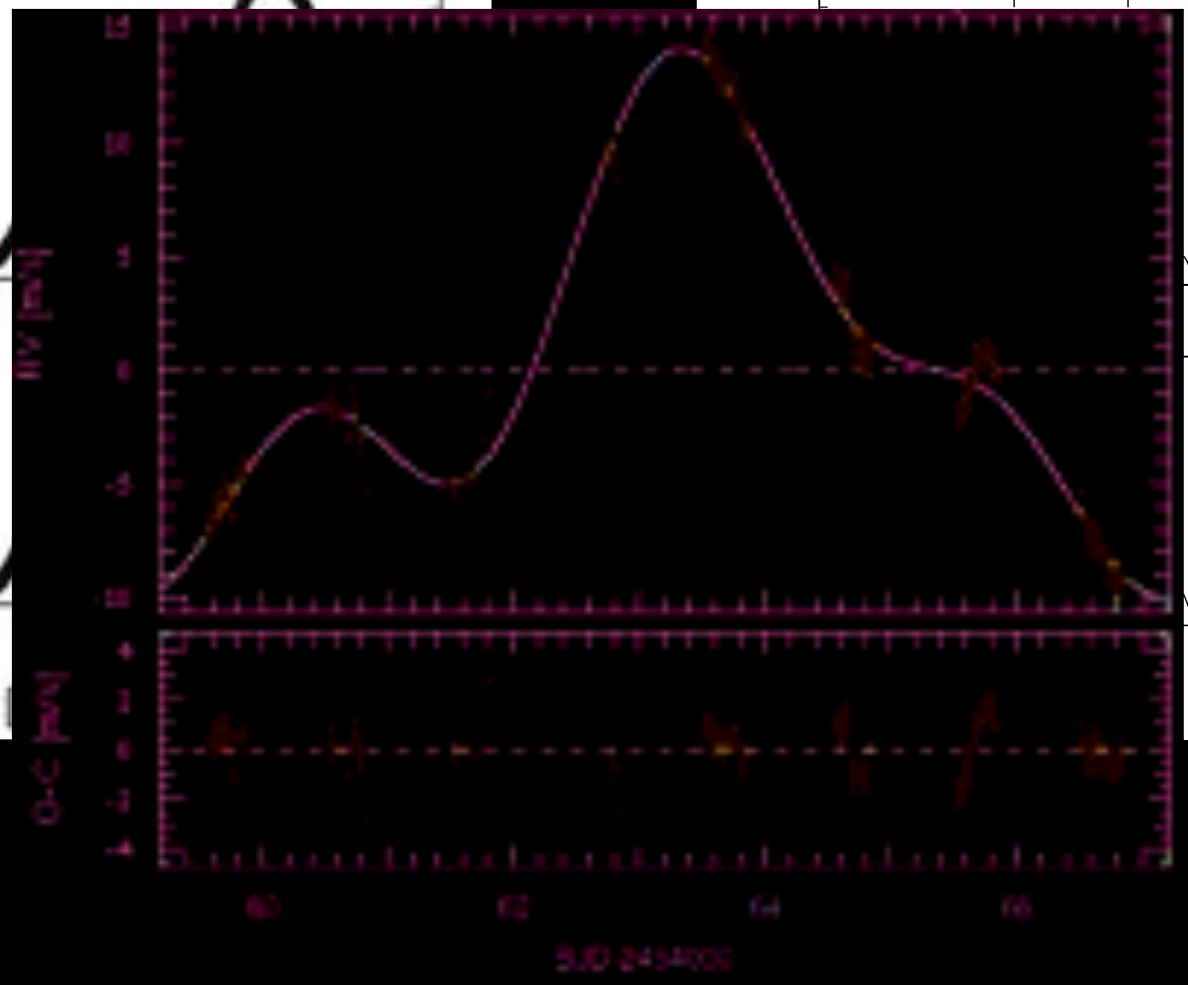


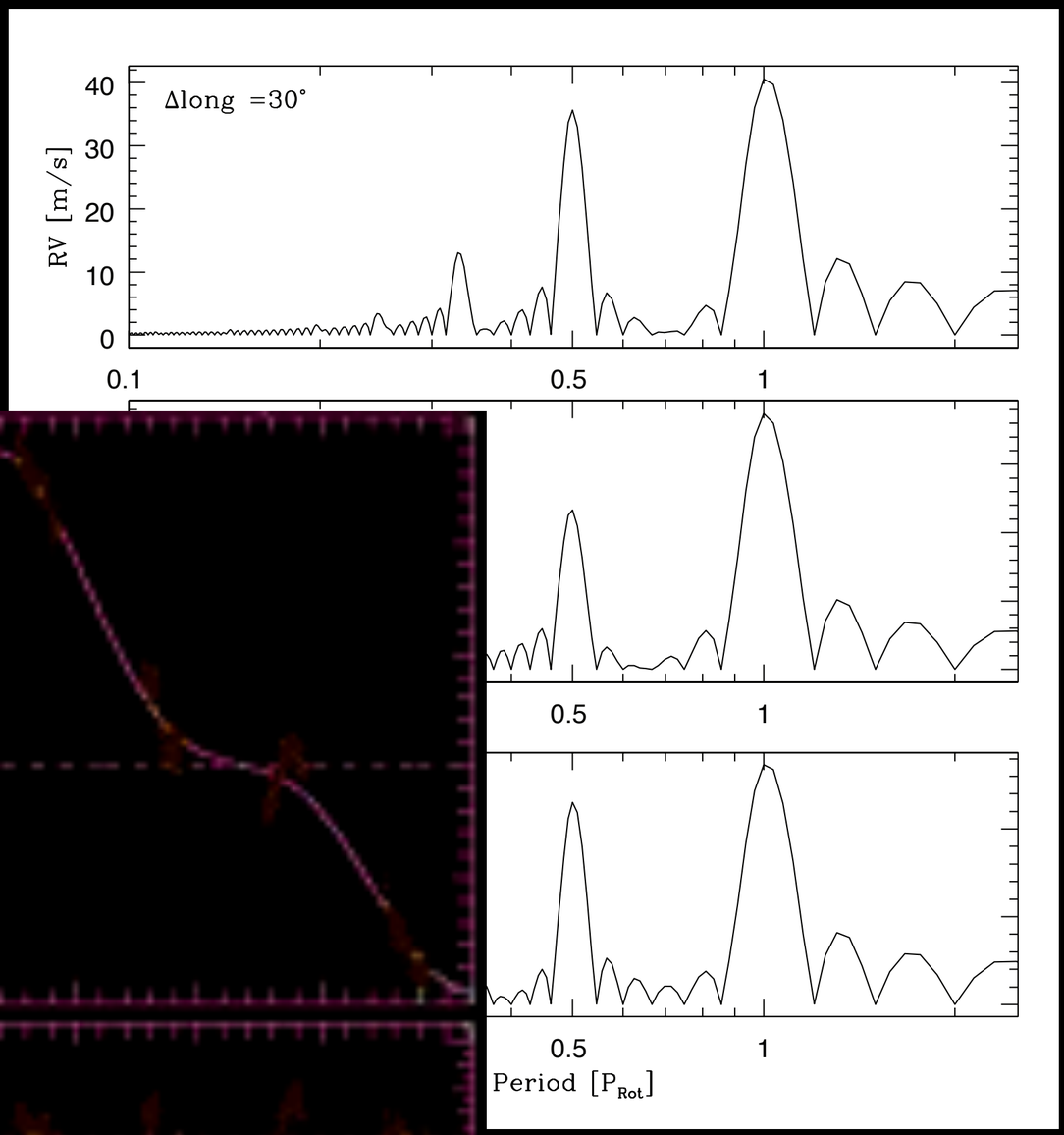


Boisse et al. 2011

Fitting sine waves to reduced rotational activity







Boisse et al. 2011

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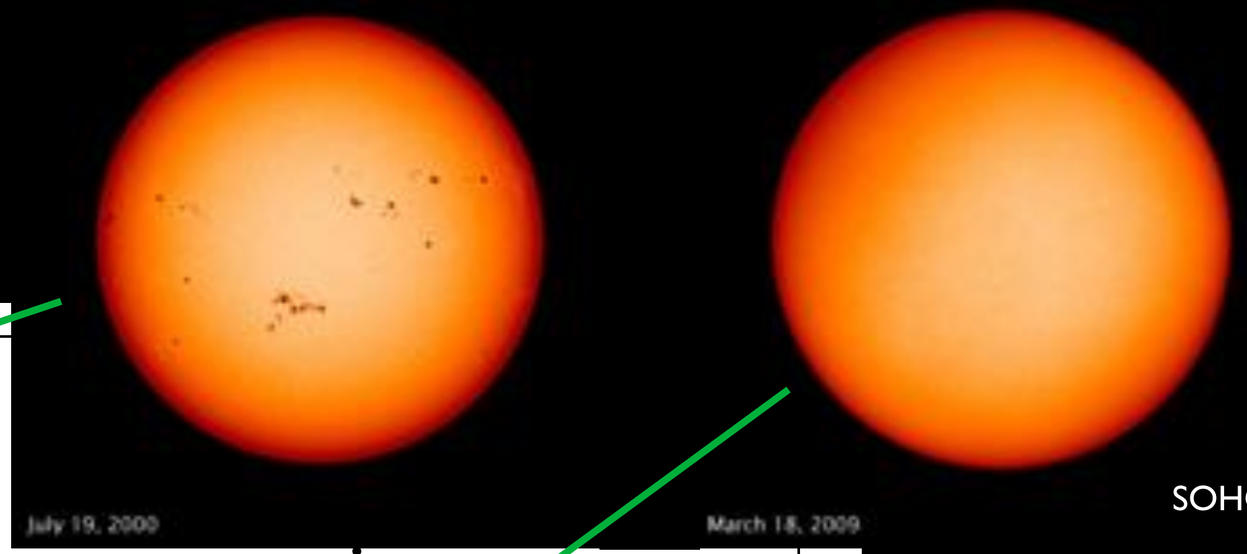
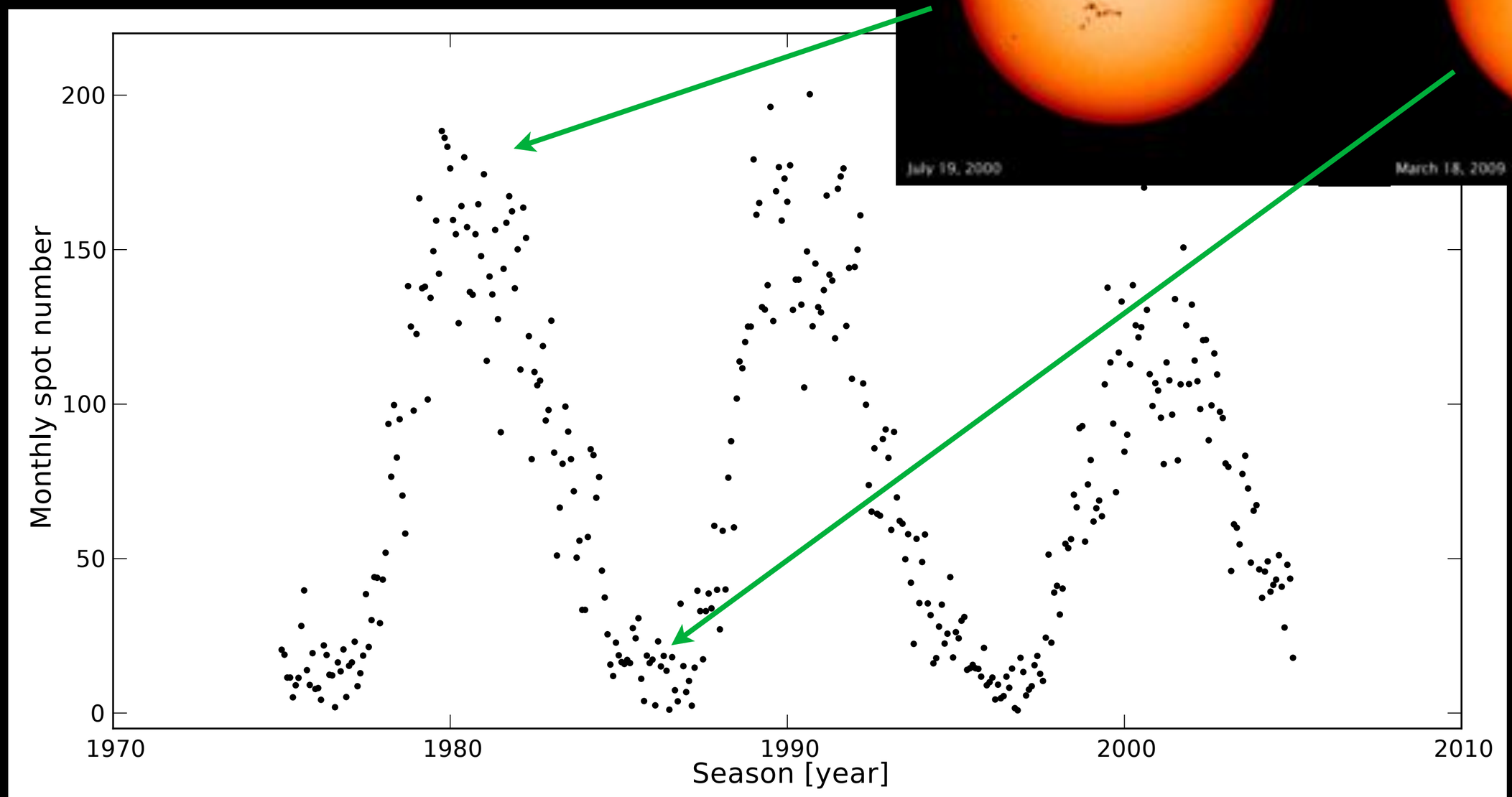
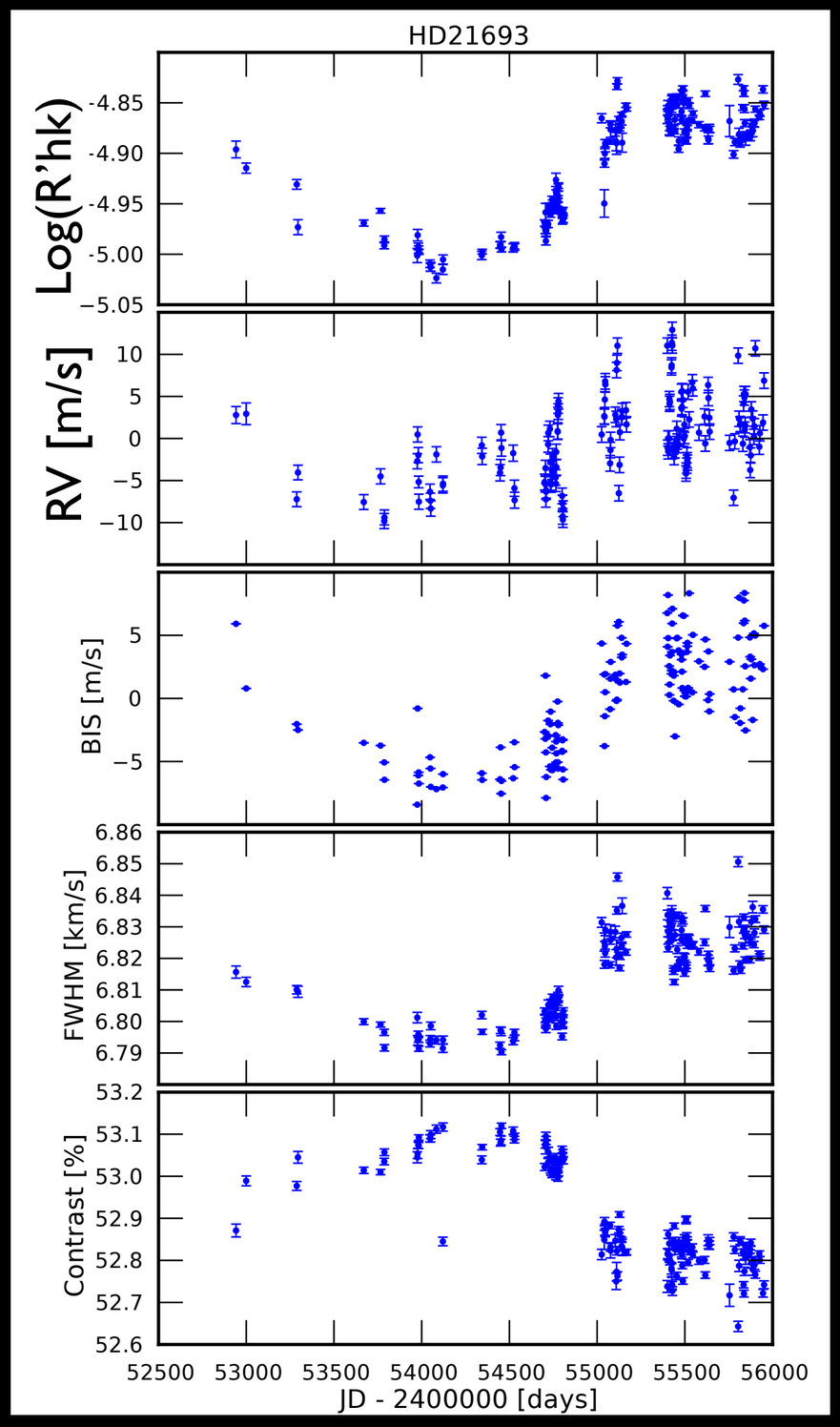
Solar magnetic cycles

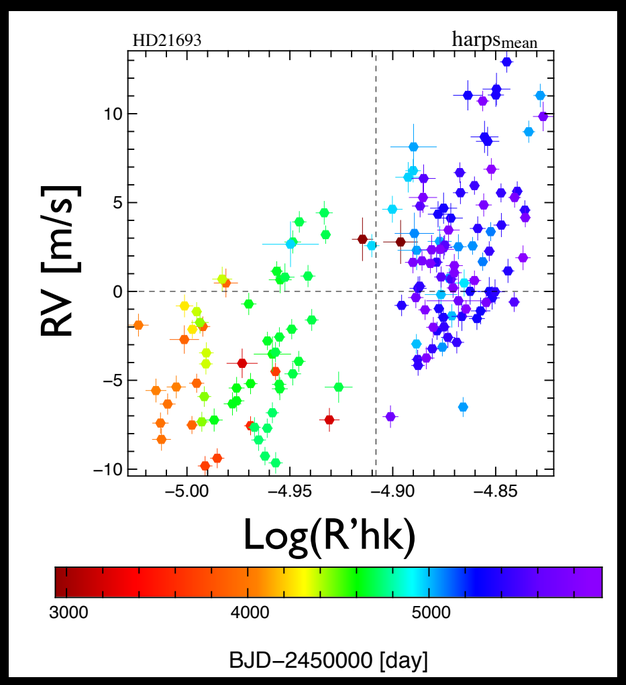


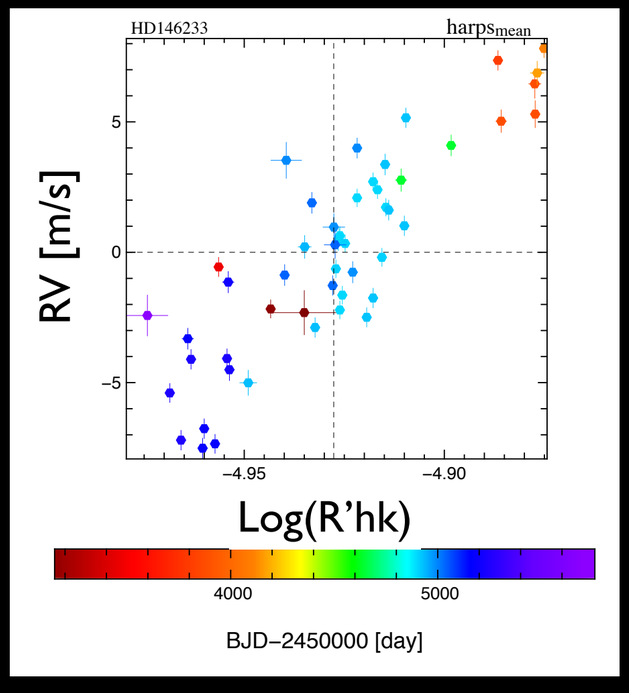


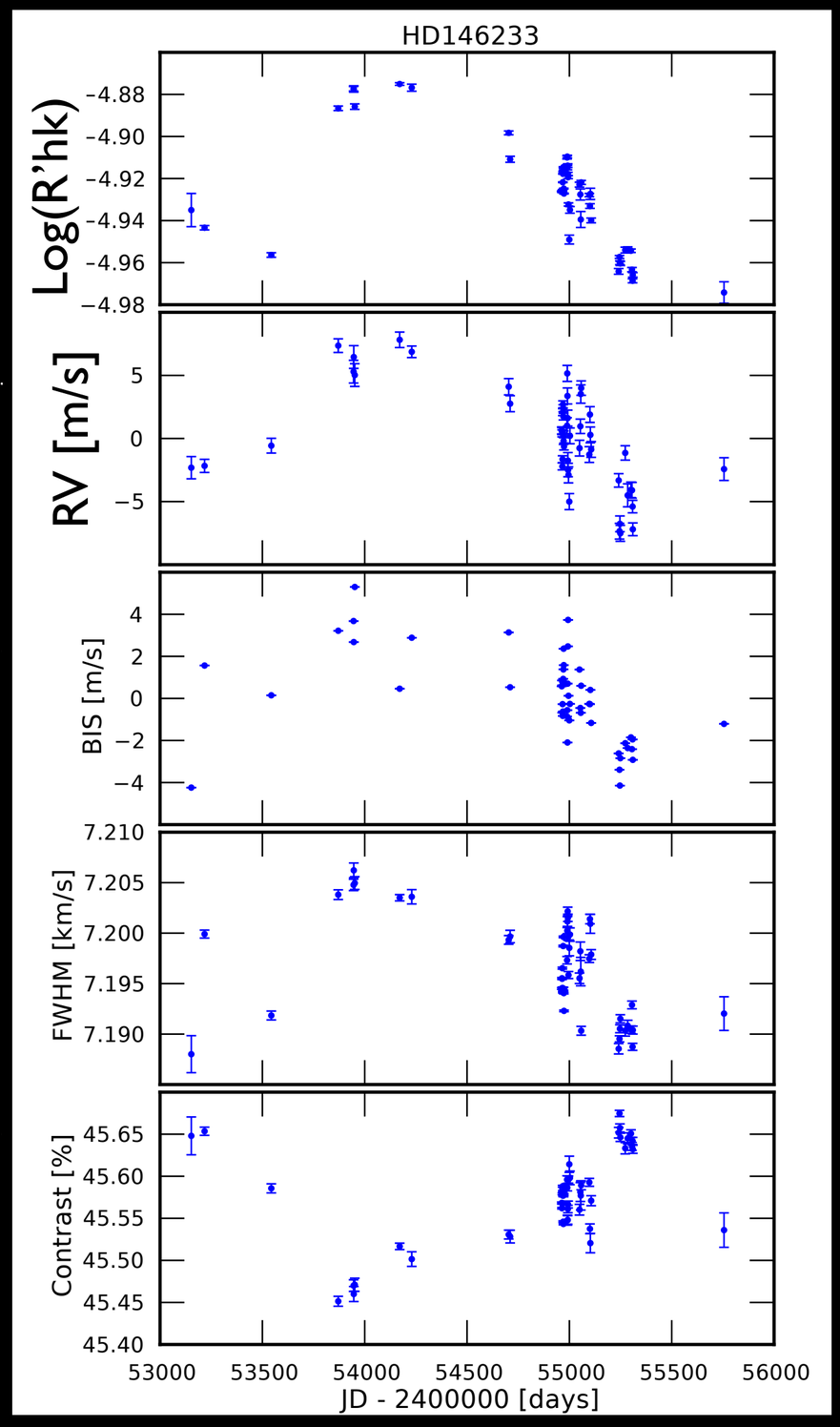
Loockwood 2007

Activity index - radial velocity correlation









Lovis et al. 2011

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The planet orbiting Alpha Centauri B

G. Lambert, ESO/L. Calçada

The planet orbiting Alpha Centauri B

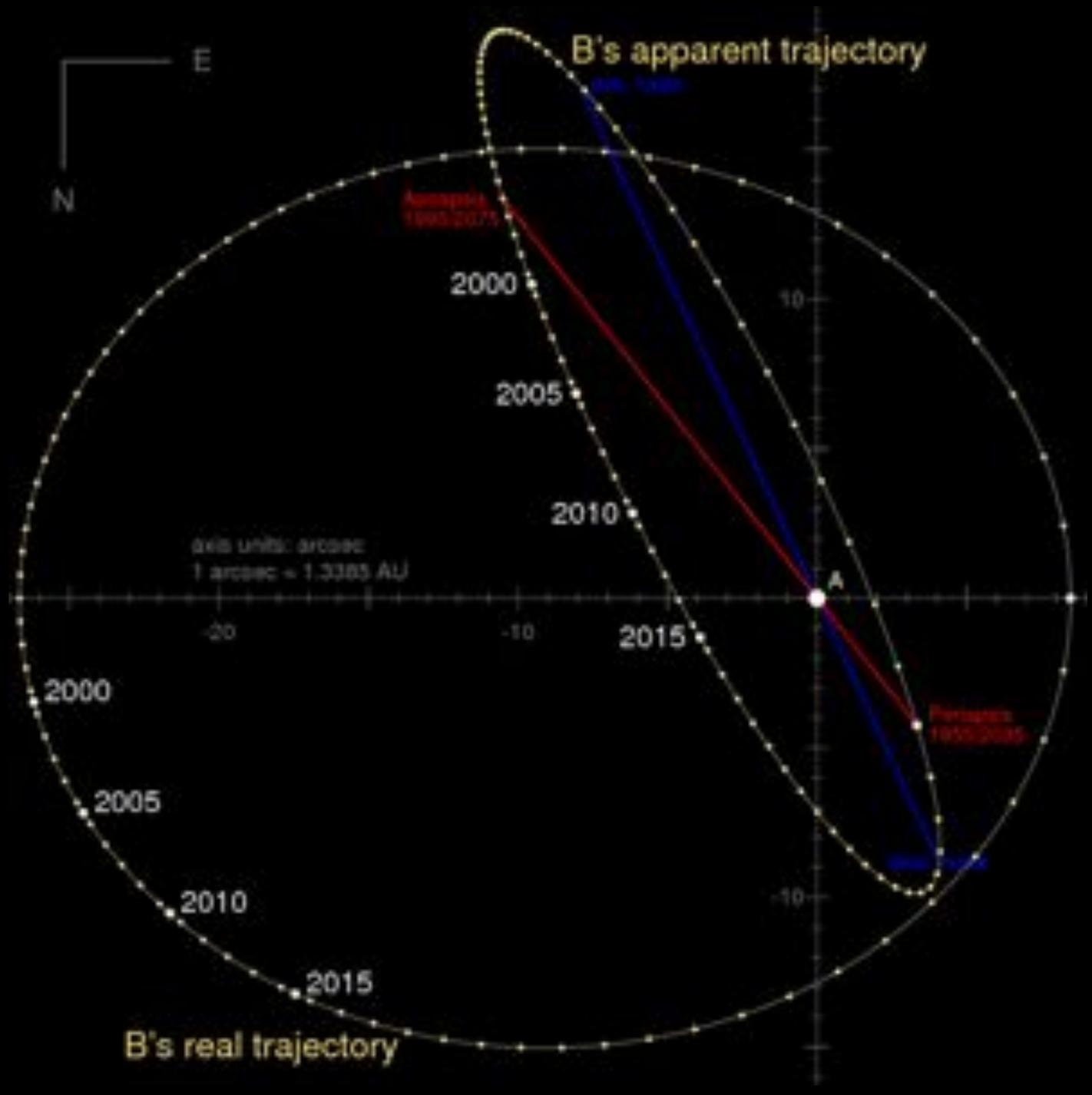
G. Lambert, ESO/L. Calçada

Why Alpha Centauri B?

- Why Alpha Centauri B is interesting to look for planets?
  - K dwarfs: lower level of stellar signals
  - Minimum activity level in 2008
  - Very bright: one of our closest neighbor

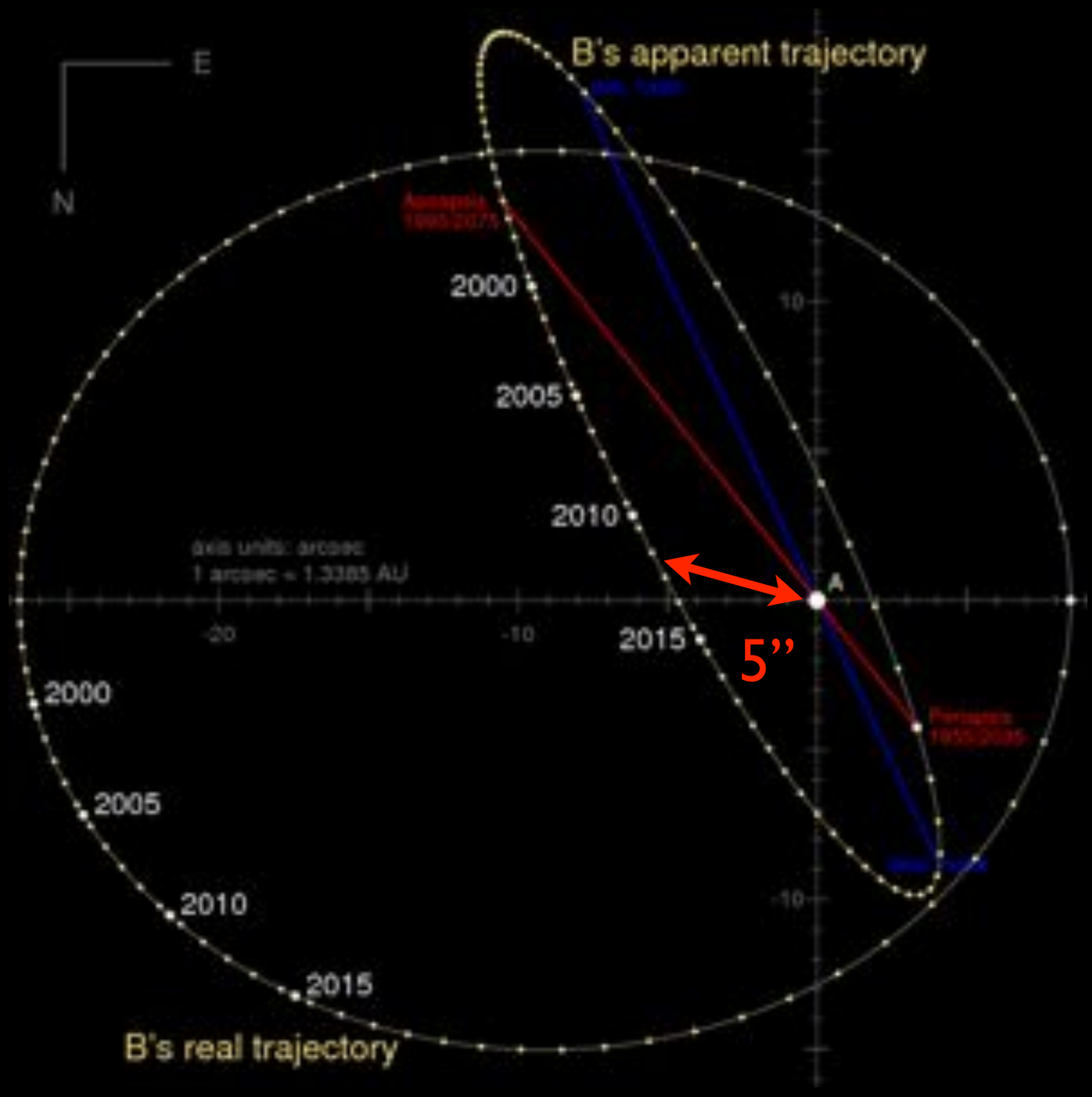
3 meas./night strategy + 4 years → ~ 500 meas.

Binarity



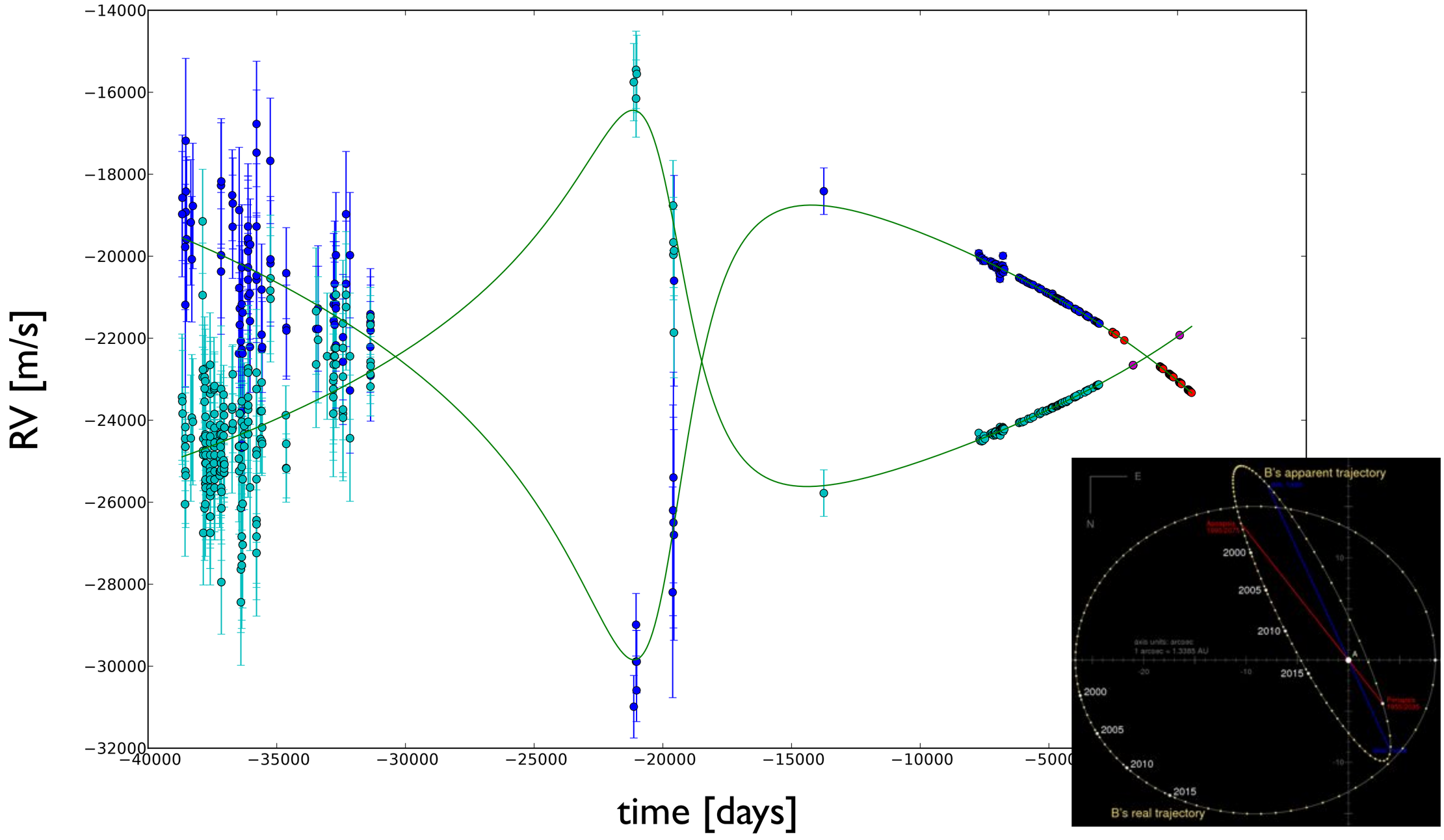
Pourbaix et al. 2002

Binarity



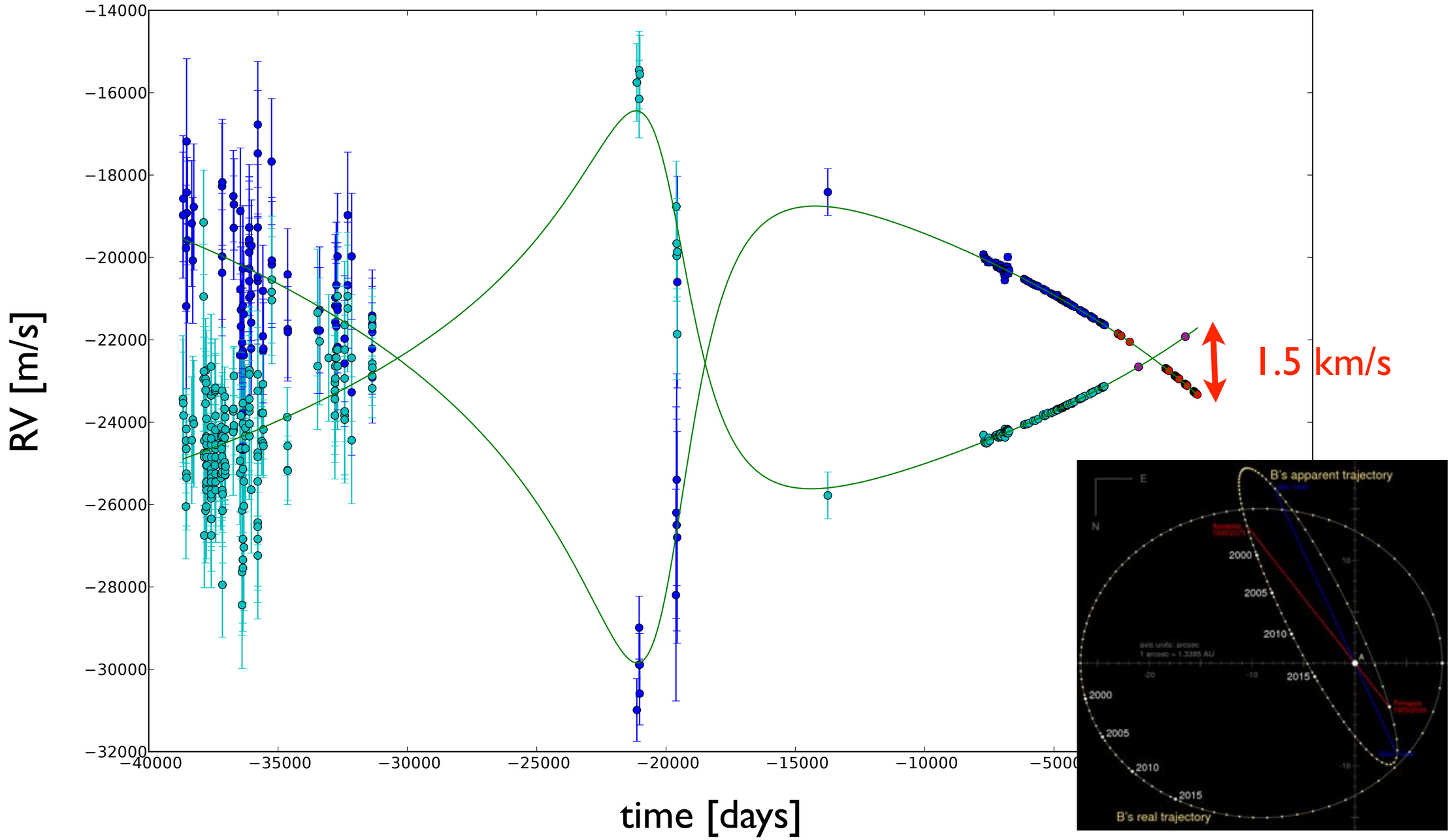
Pourbaix et al. 2002

Binarity



Pourbaix et al. 2002

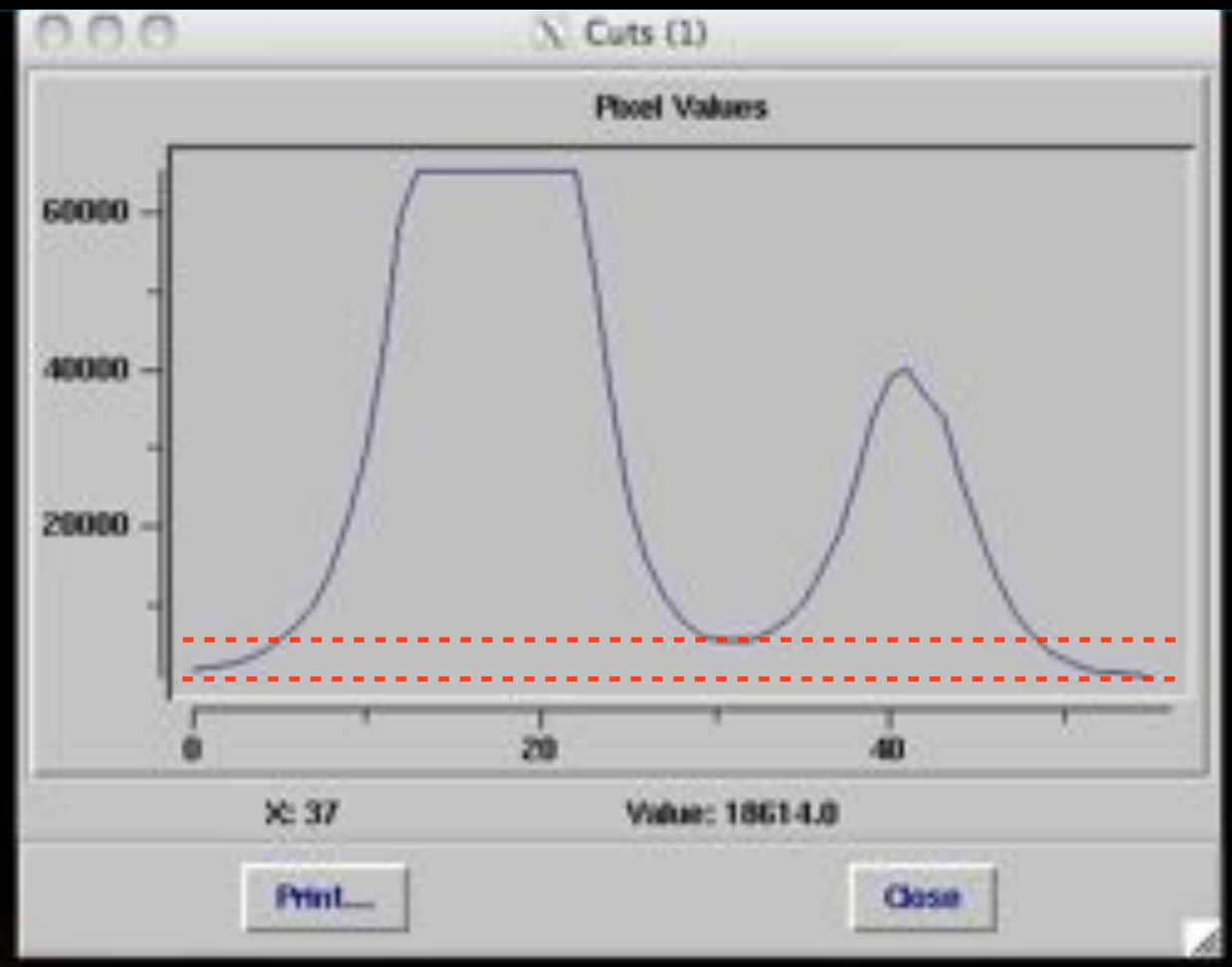
Binarity



Pourbaix et al. 2002

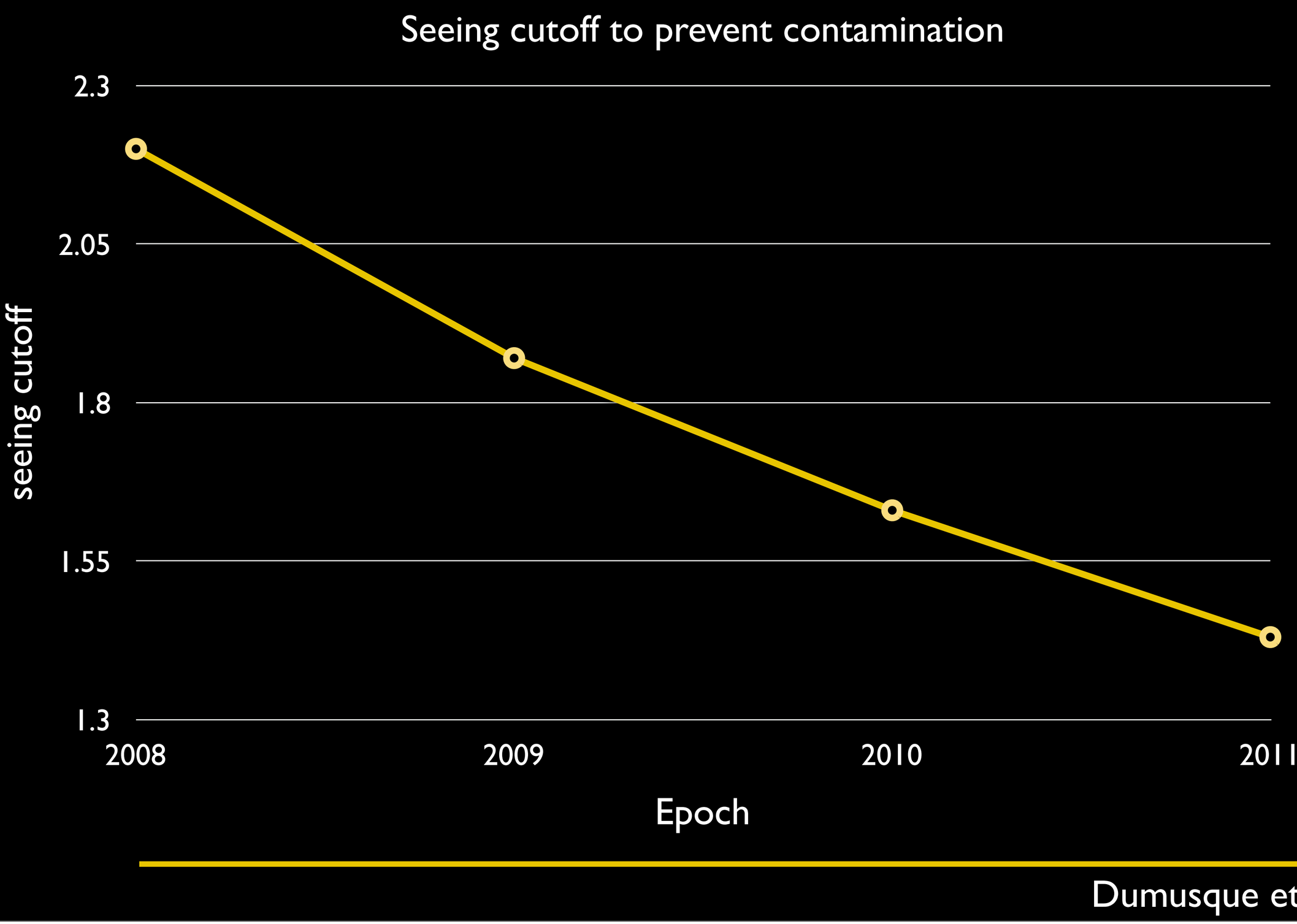
Contamination

seeing ~2”



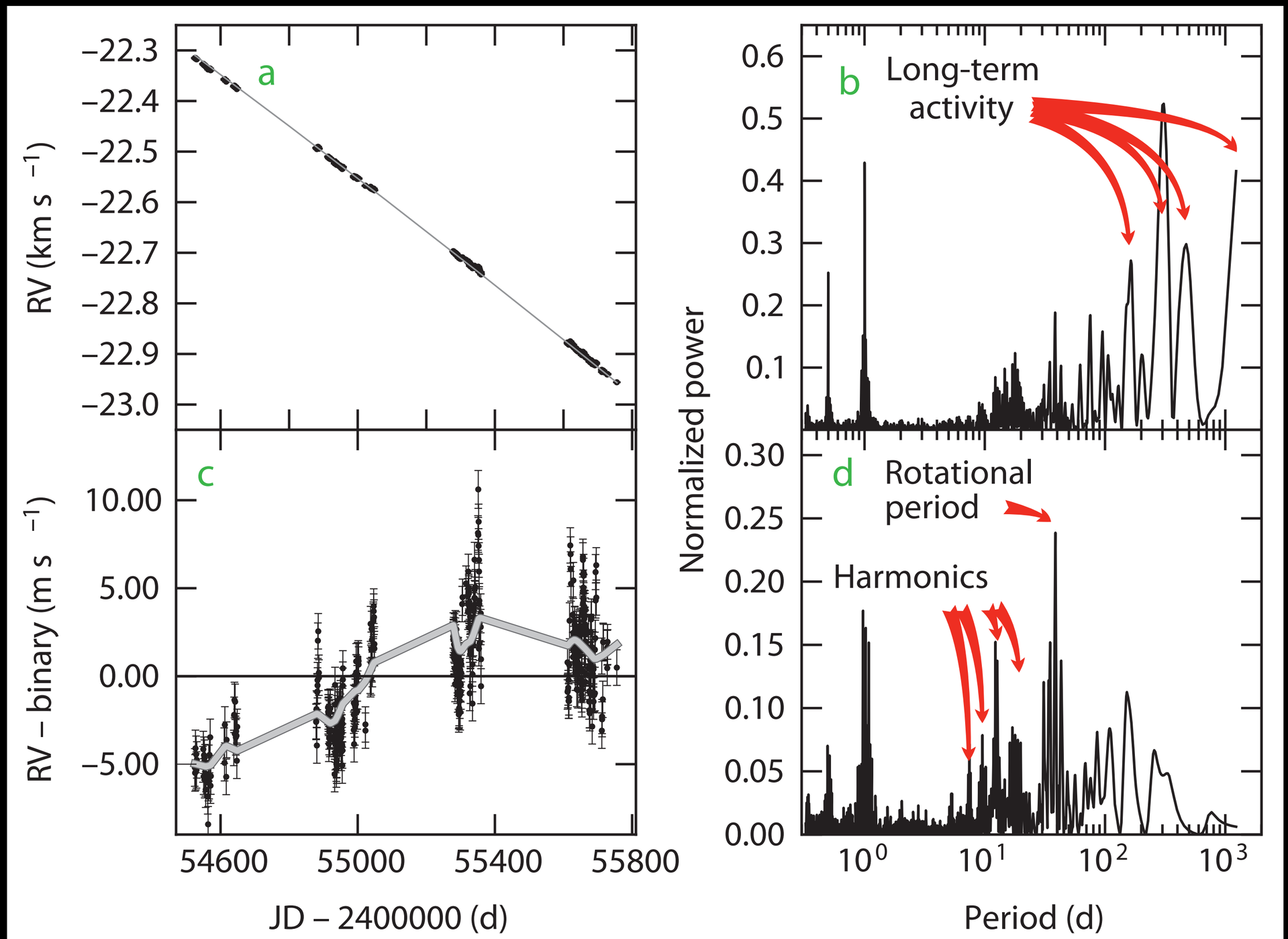
Dumusque et al. 2012

Contamination



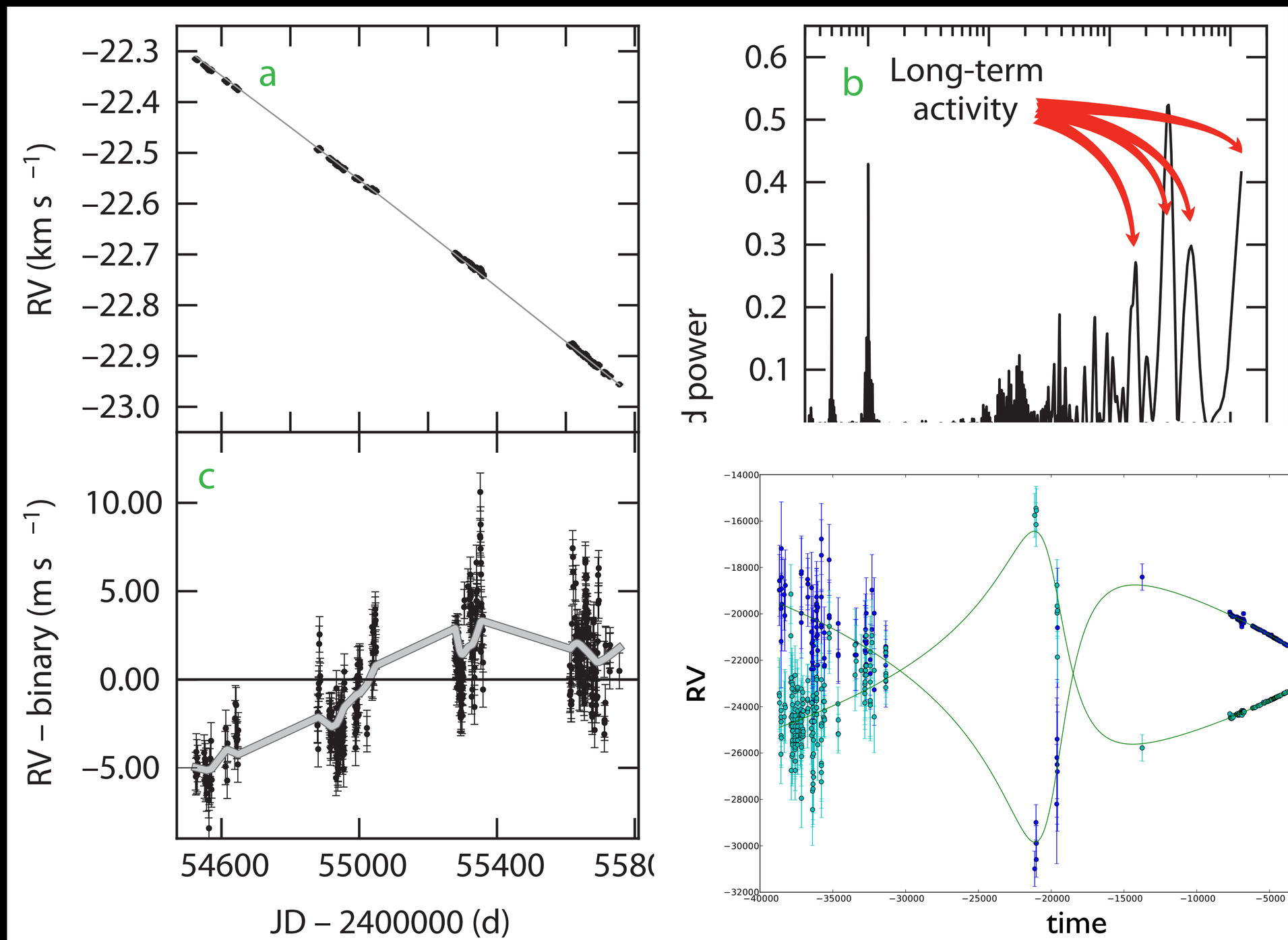
Dumusque et al. 2012

Fit the binary and the magnetic cycle effects



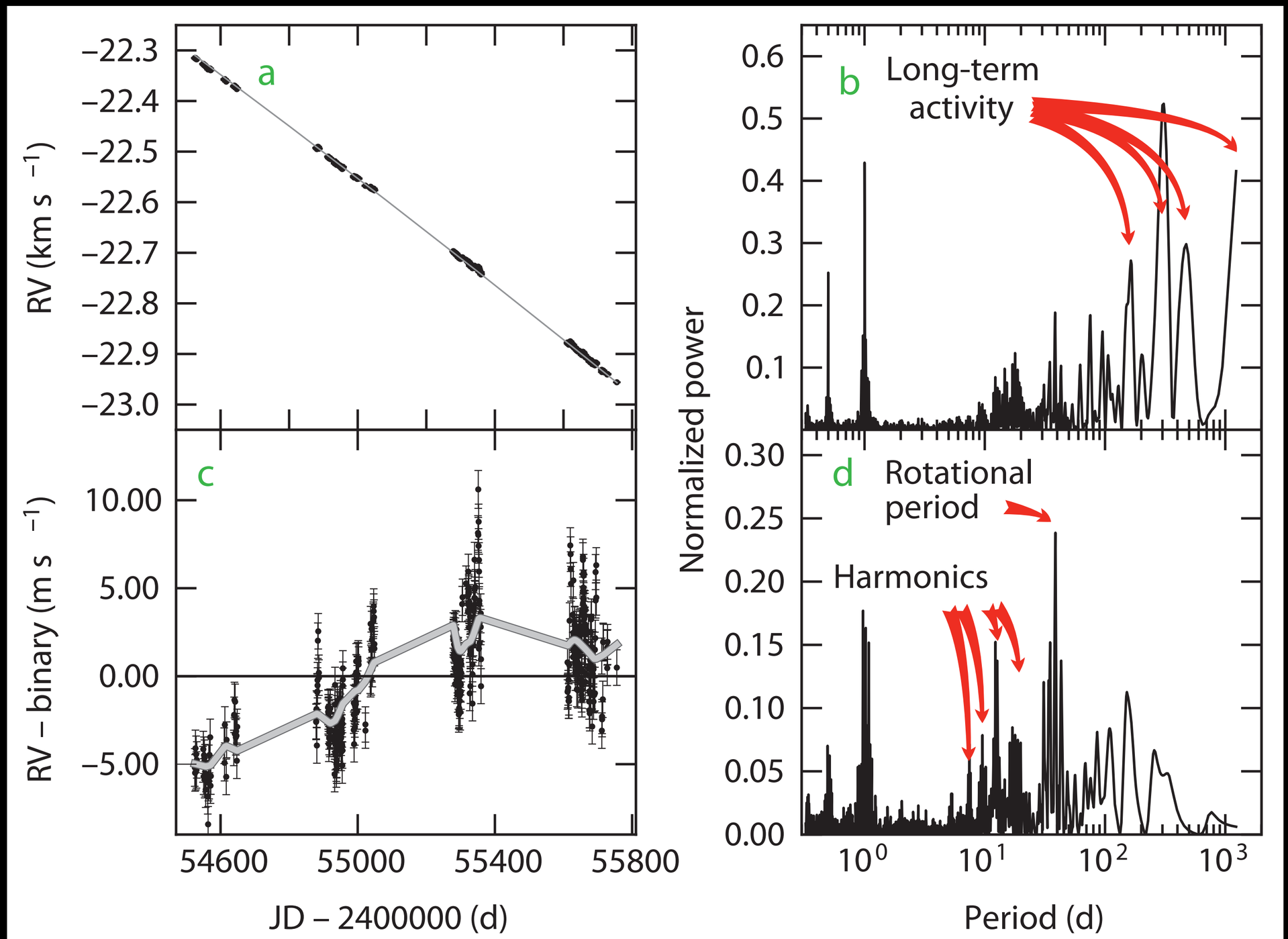
Dumusque et al. 2012

Fit the binary and the magnetic cycle effects



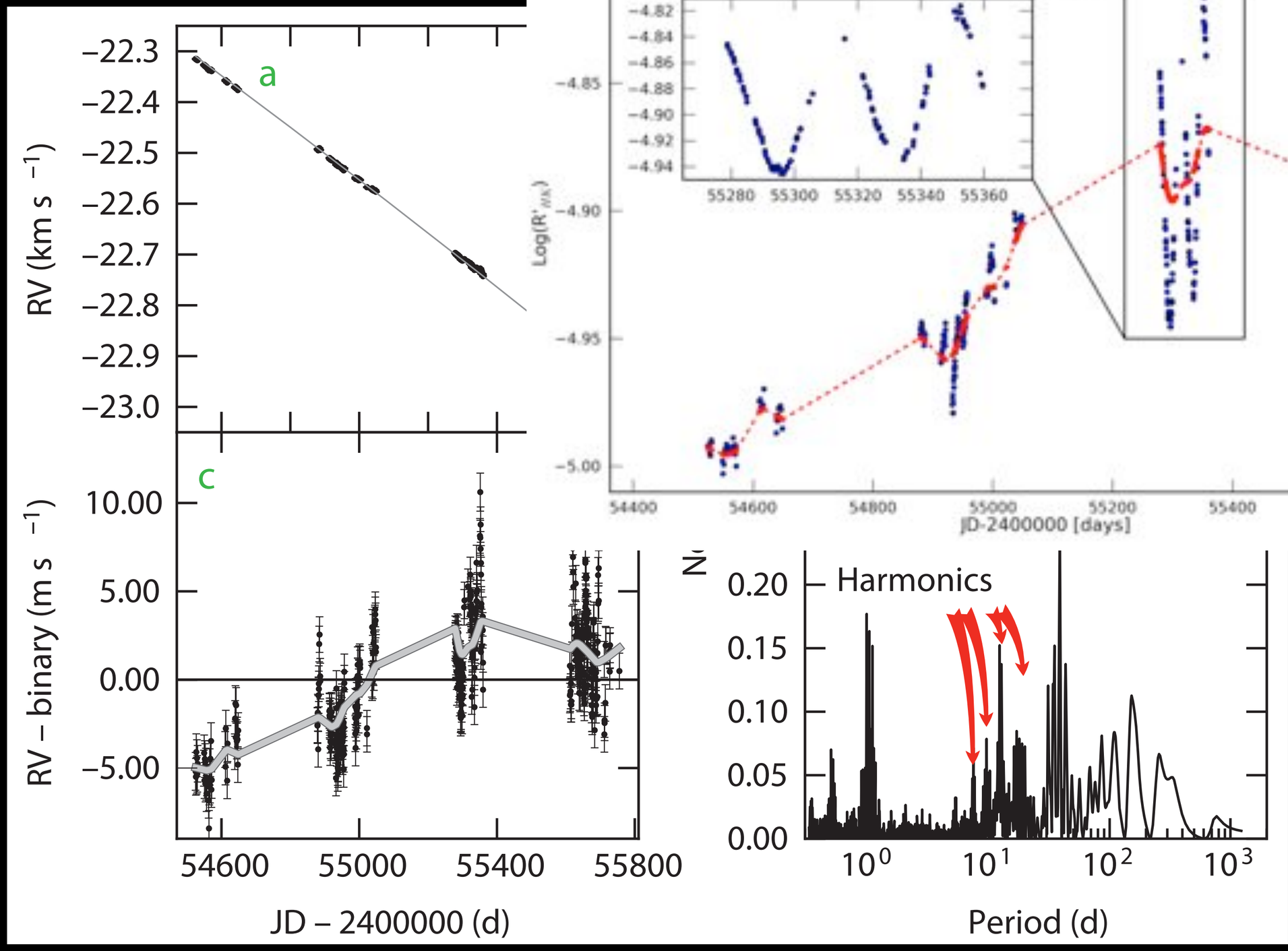
Dumusque et al. 2012

Fit the binary and the magnetic cycle effects



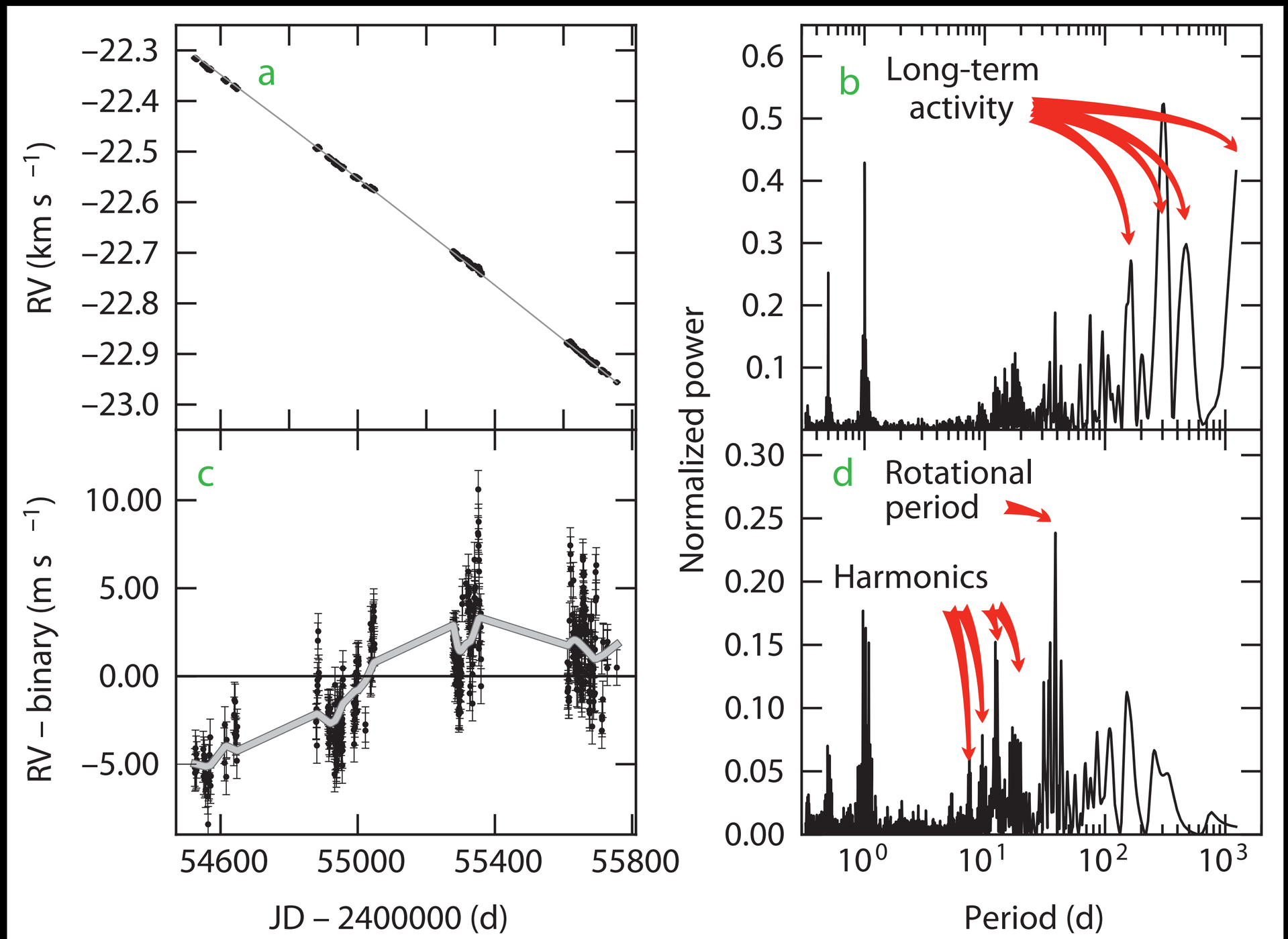
Dumusque et al. 2012

Fit the binary and the magnetic cycle effects



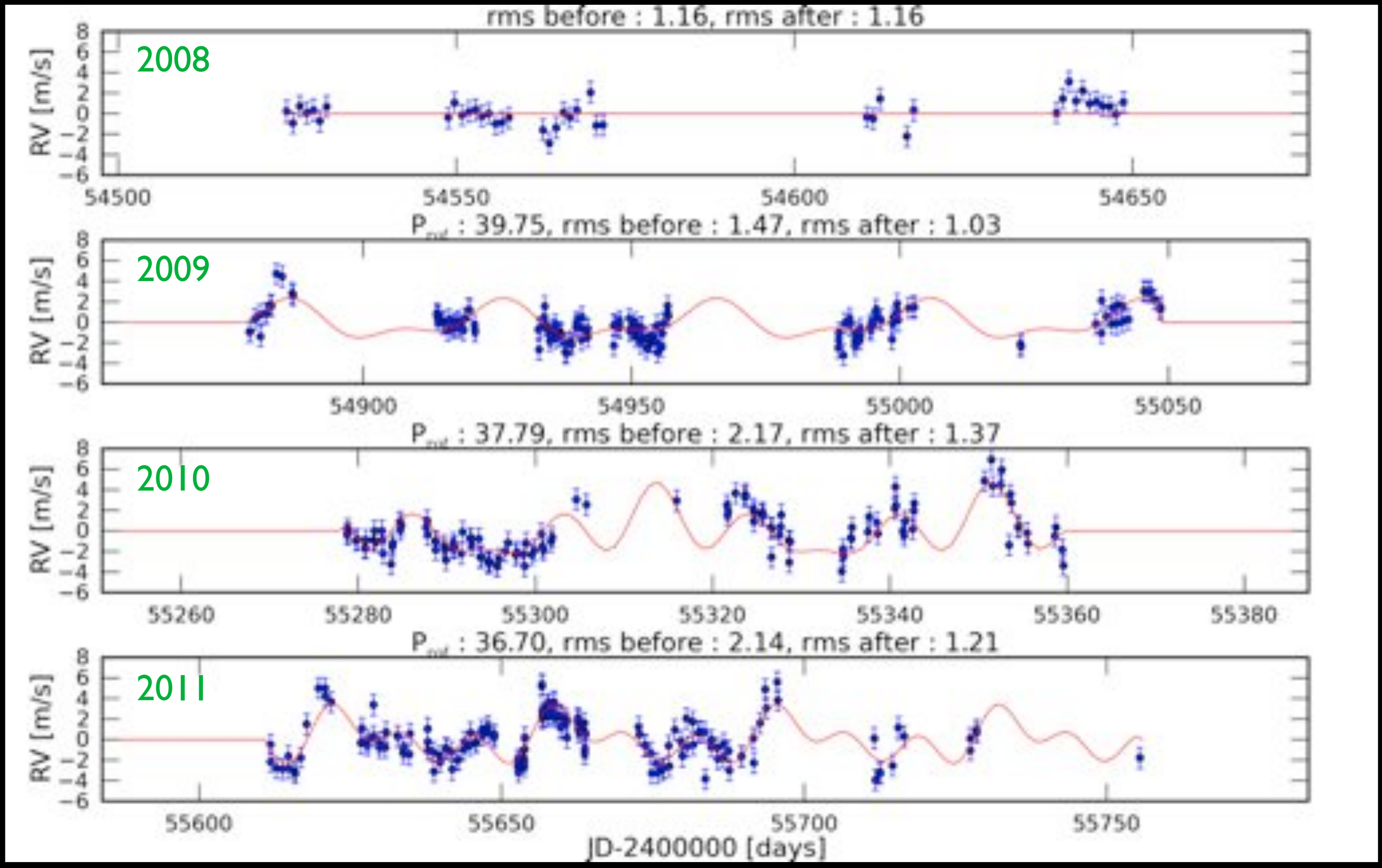
Dumusque et al. 2012

Fit the binary and the magnetic cycle effects



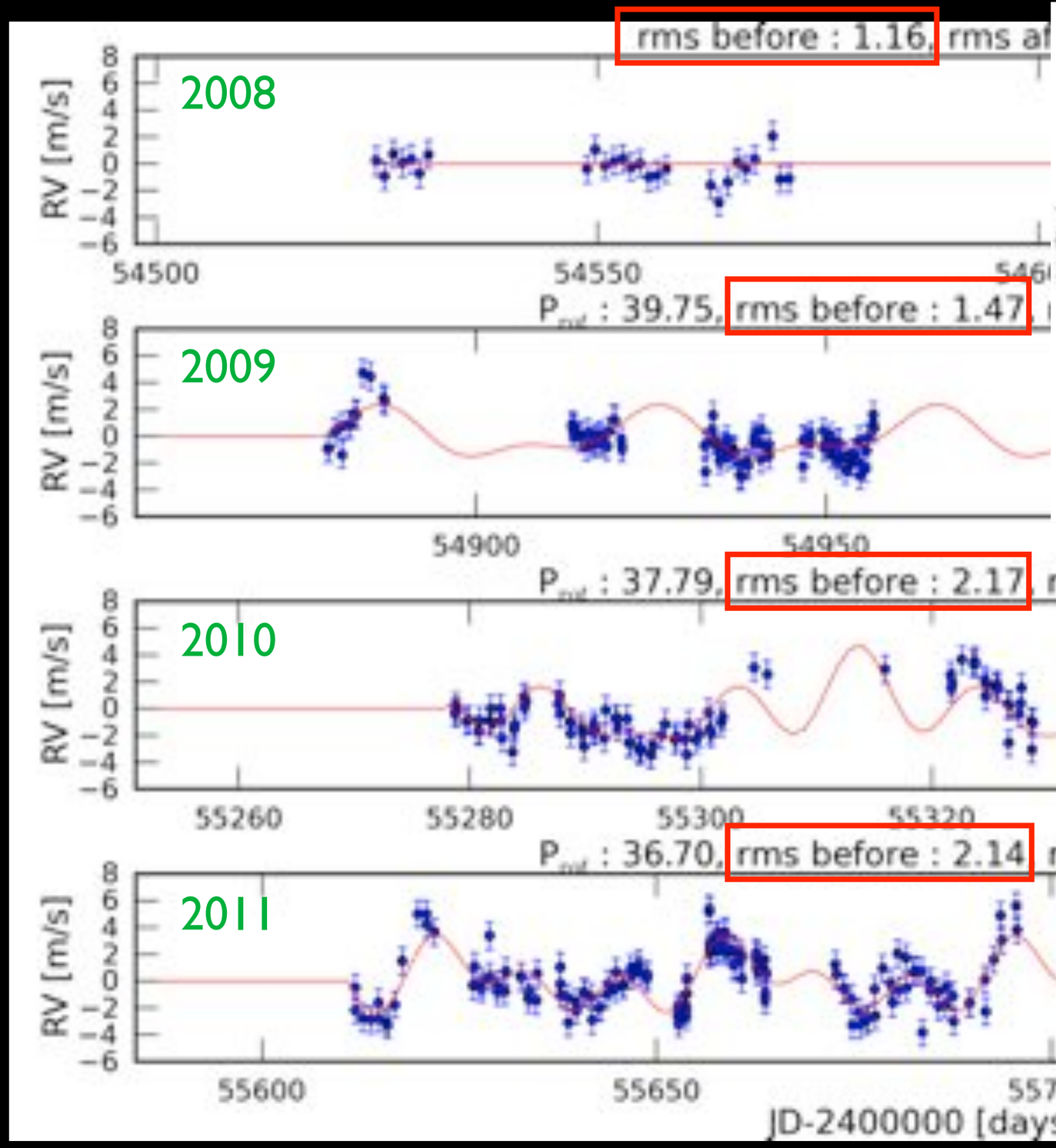
Dumusque et al. 2012

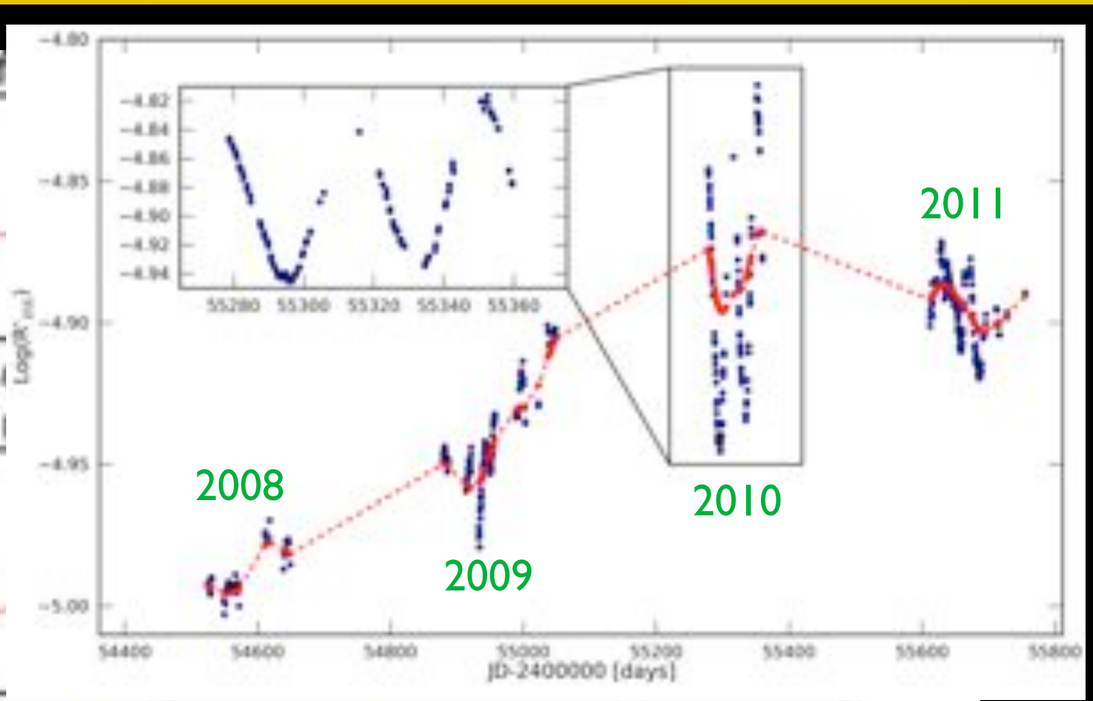
Fit rotational activity signal



Dumusque et al. 2012

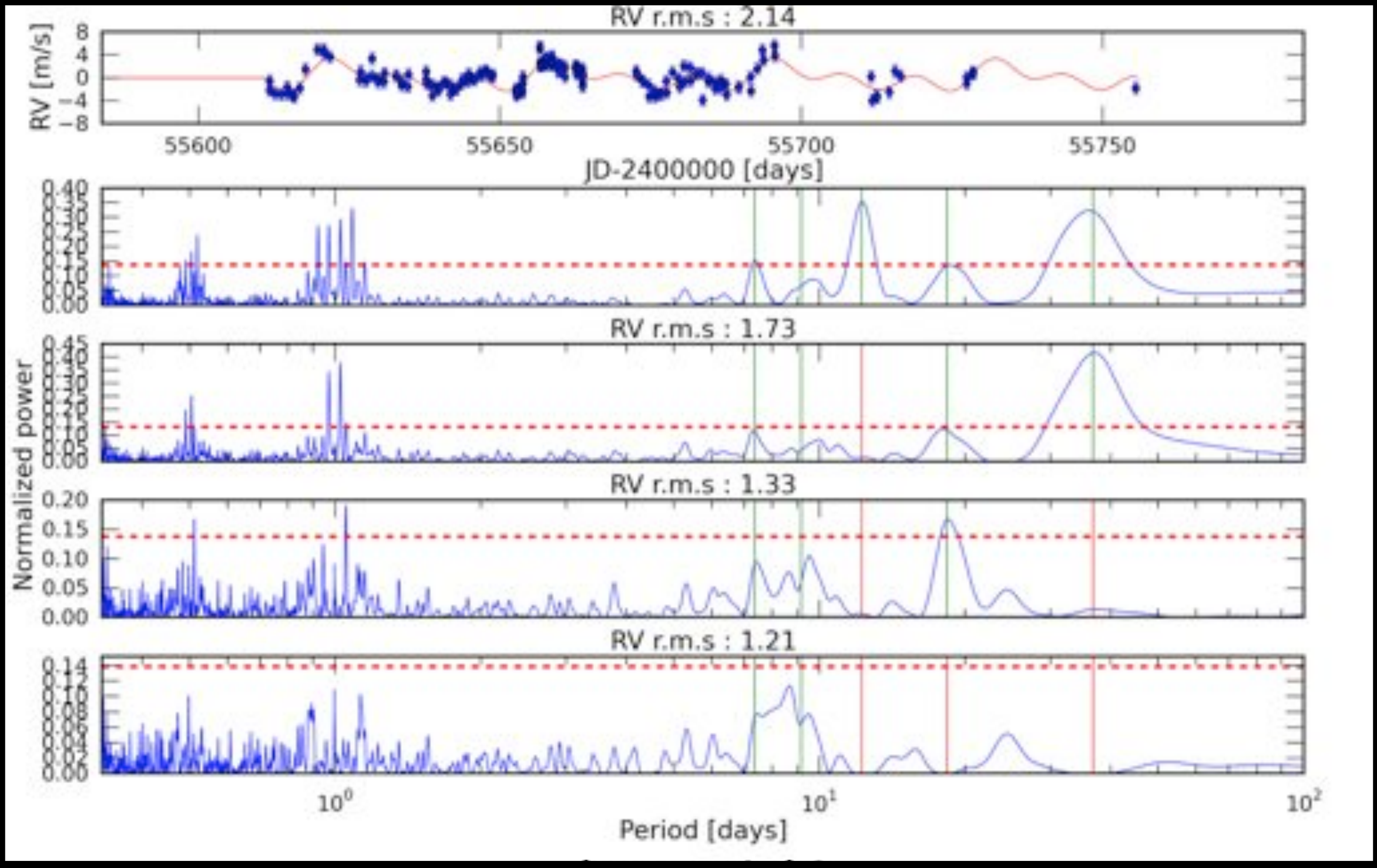
Fit rotational activity signal





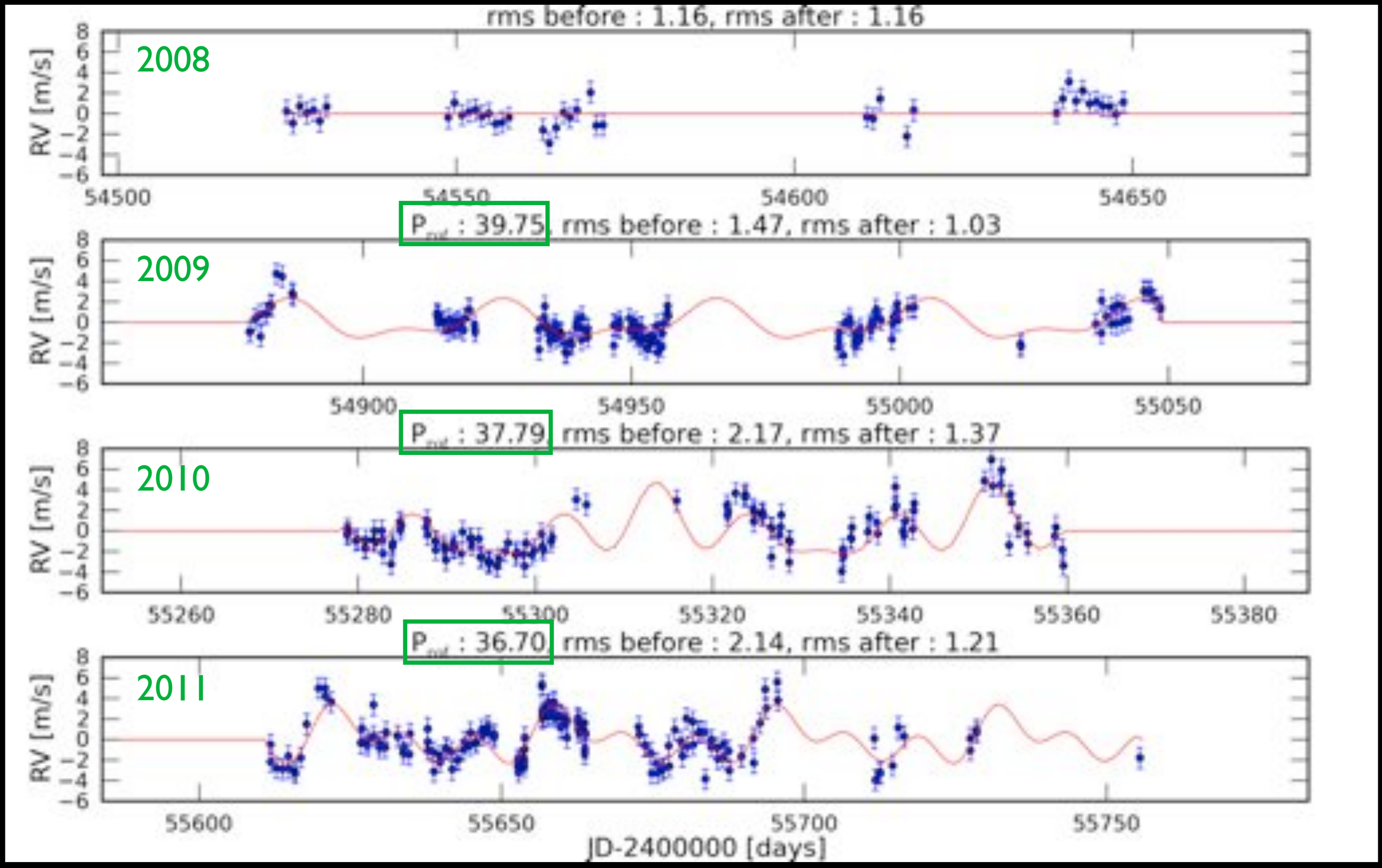
Dumusque et al. 2012

Fit rotational activity signal



Dumusque et al. 2012

Fit rotational activity signal



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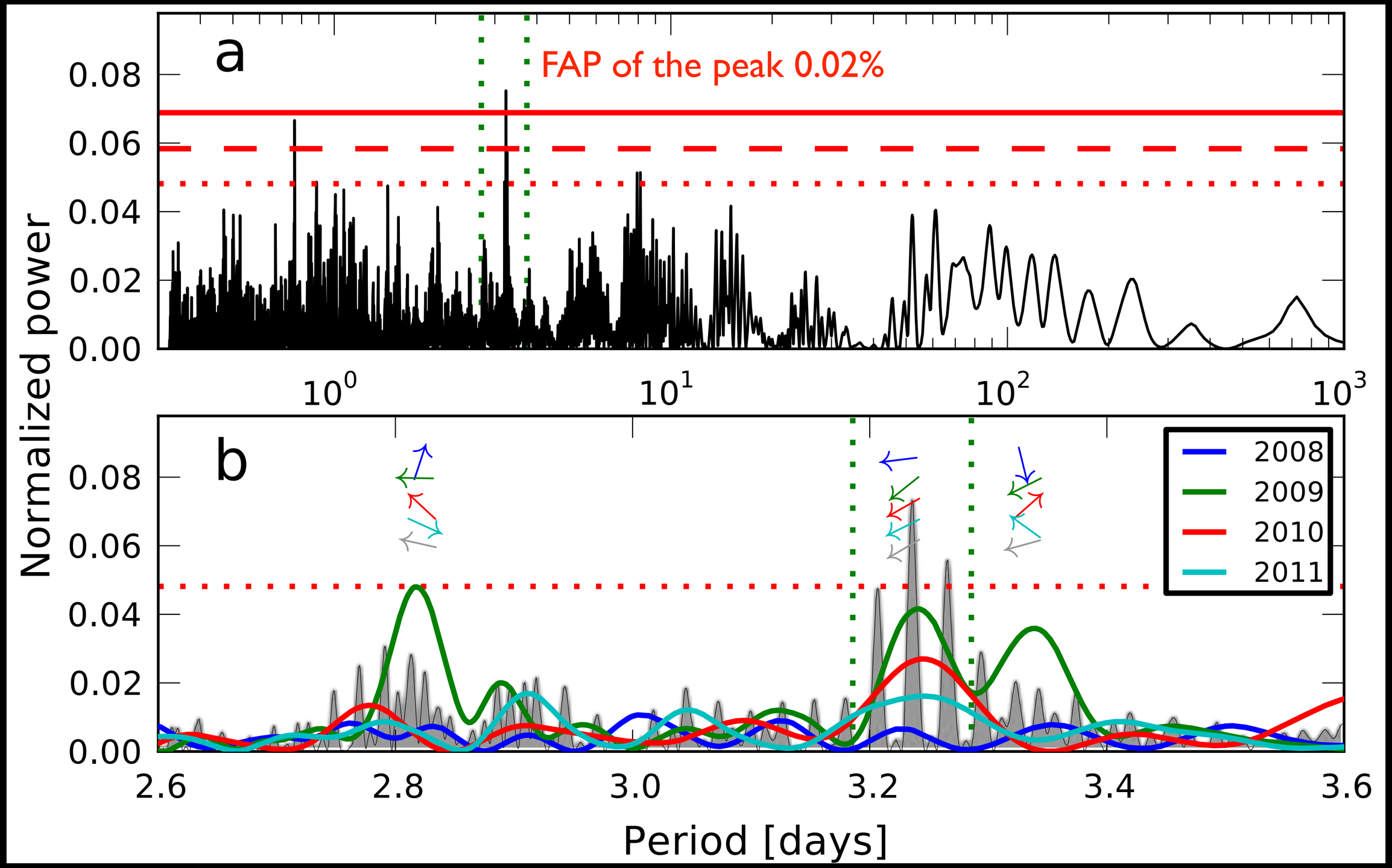
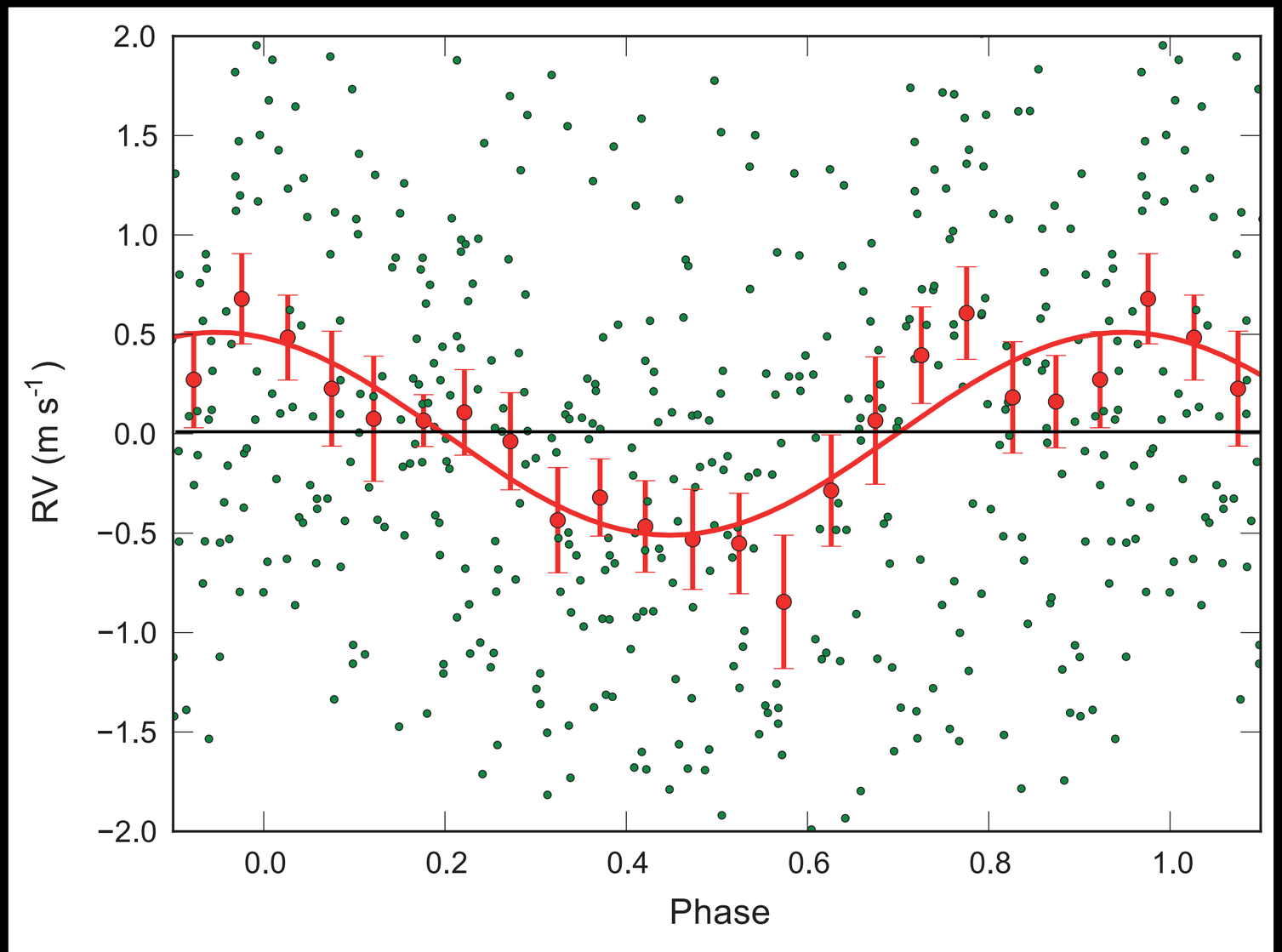
The planetary signal

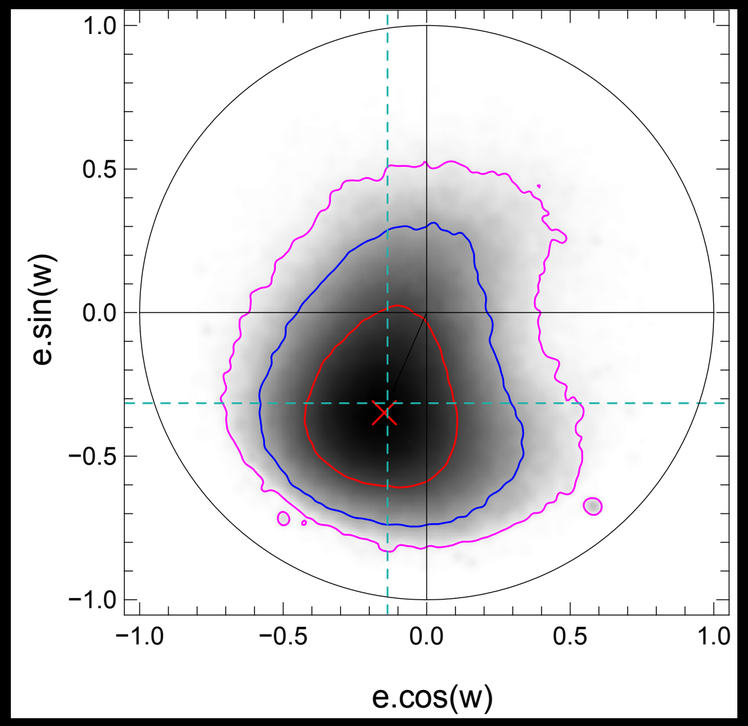


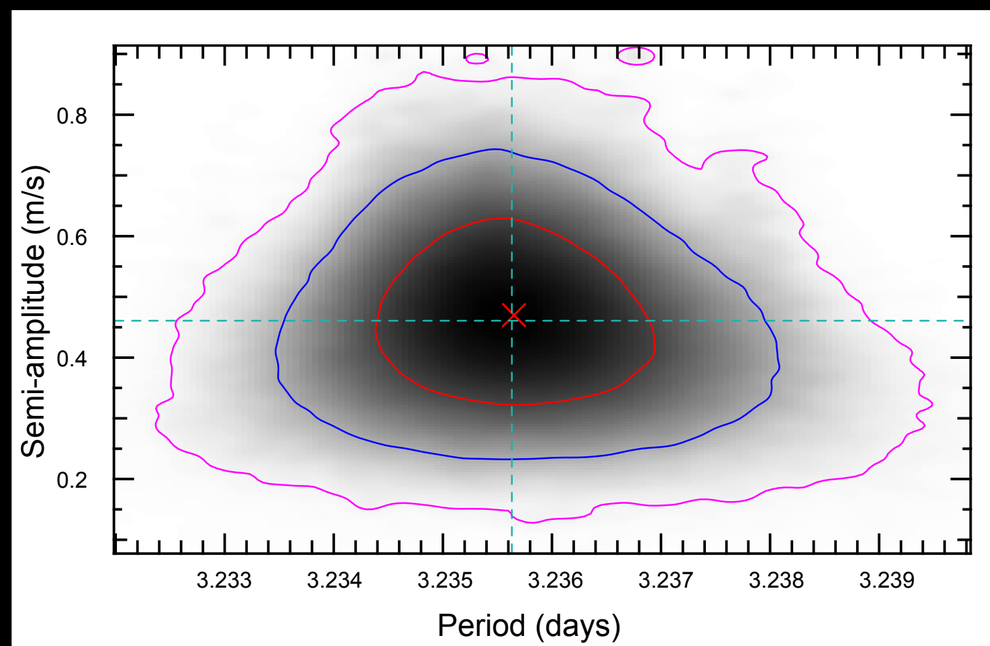
The planetary signal

One Earth mass, 3.2 days of period



0.5 m/s





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Outline

- Detection techniques
- Stellar signals
  - Stellar oscillations
  - Granulation phenomena
  - Rotational activity signal
  - Magnetic cycles
- The Earth-mass planet orbiting Alpha Centauri B
- Conclusions

Conclusion

- The effect of Alpha Centauri B b is 50 cm/s

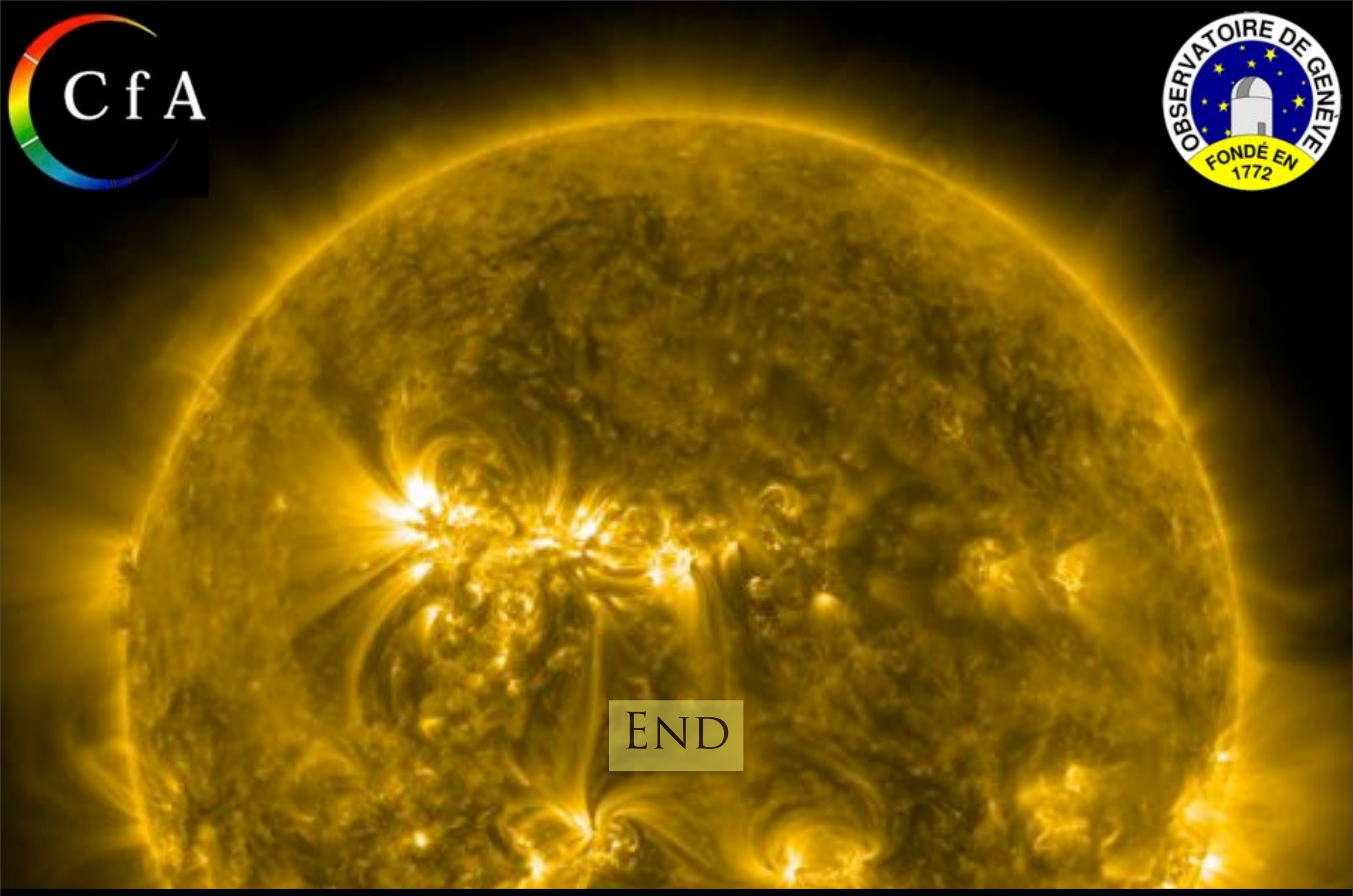
Earth is 10 cm/s

- Precision of HARPS ~80 cm/s. We need a new instrument

ESPRESSO in 2016 (10 cm/s)

- Stellar signals of a few m/s

Understanding stellar signals and reducing their effects is a mandatory step if Earths-twin planets want to be detected in the near future



END

Xavier Dumusque