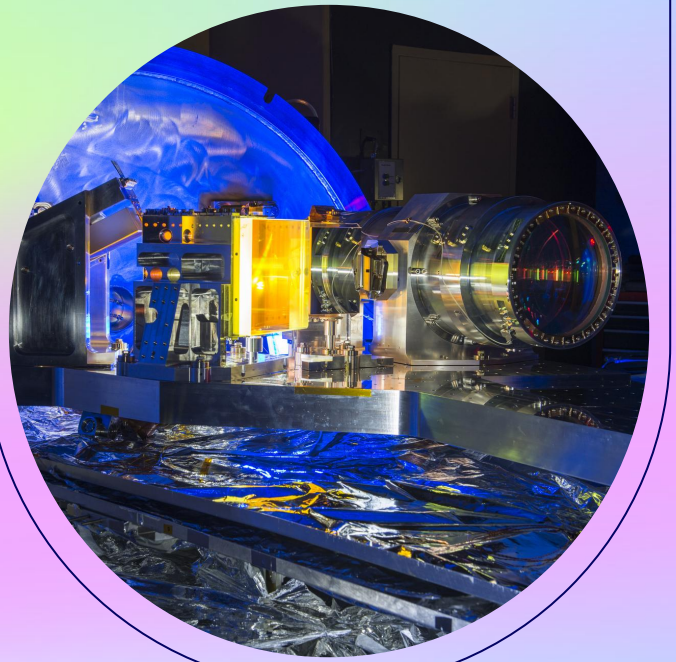
Latest news from **SPIRou**

with new planet detections

Paul **CHARPENTIER**

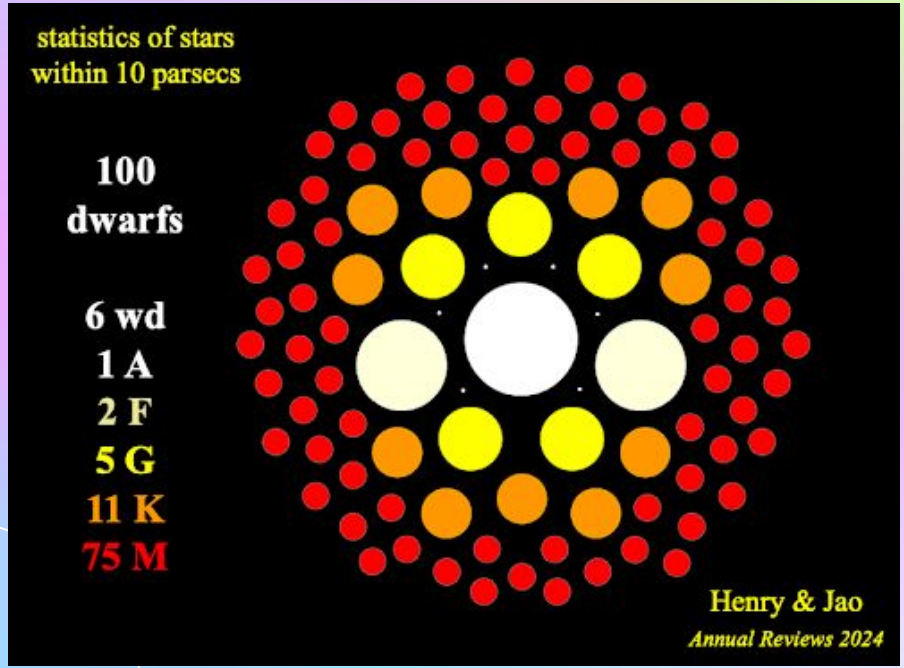
SPIRou, the nIR spectropolarimeter

- Wavelength range : **0.95-2.5 µm** (YJHK bands)
- Resolving power : **70 000**
- RV stability **: 1-2 m/s**
- Installed on the 3.6m telescope at CFHT since 2018
- Can simultaneously measure magnetic fields
- The SPIRou Legacy Survey (SLS)
  - 57 M dwarfs regularly observed for 310 nights (2019A - 2022A)
  - Extended with SPICE (214 nights, 2022B-2024B) and PLANETS (since 2025A)



Donati et al. (2020)

M dwarfs : promising target for the search of habitable planets



More numerous

75% of stars within 10pc

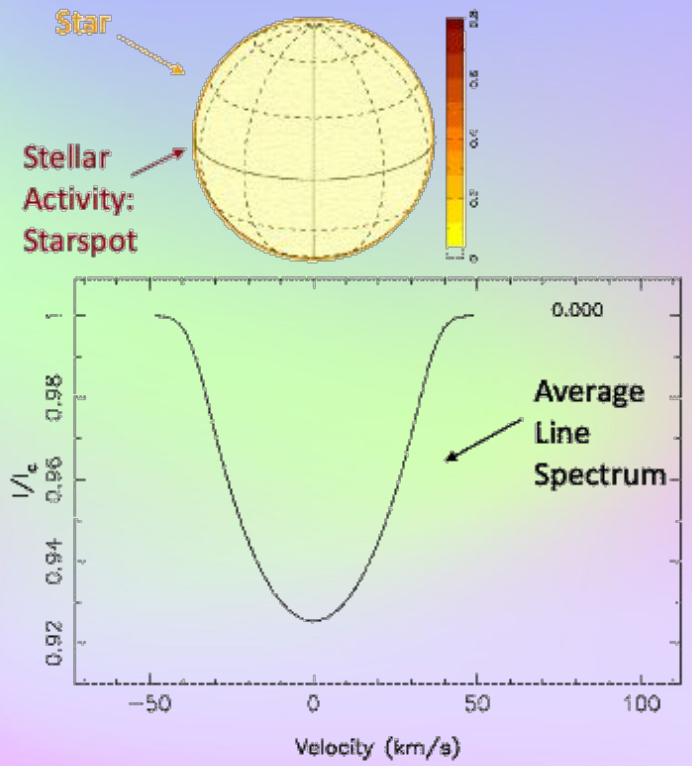
Host more planets

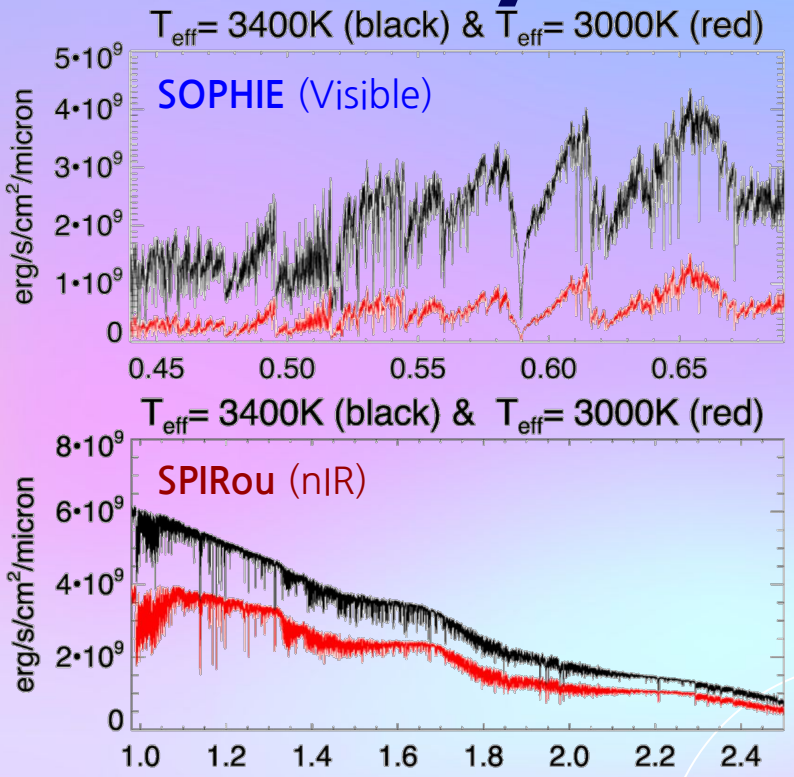
>2 times more telluric planets

Easier to detect

Increased reflex motion of the star and closer habitable zone

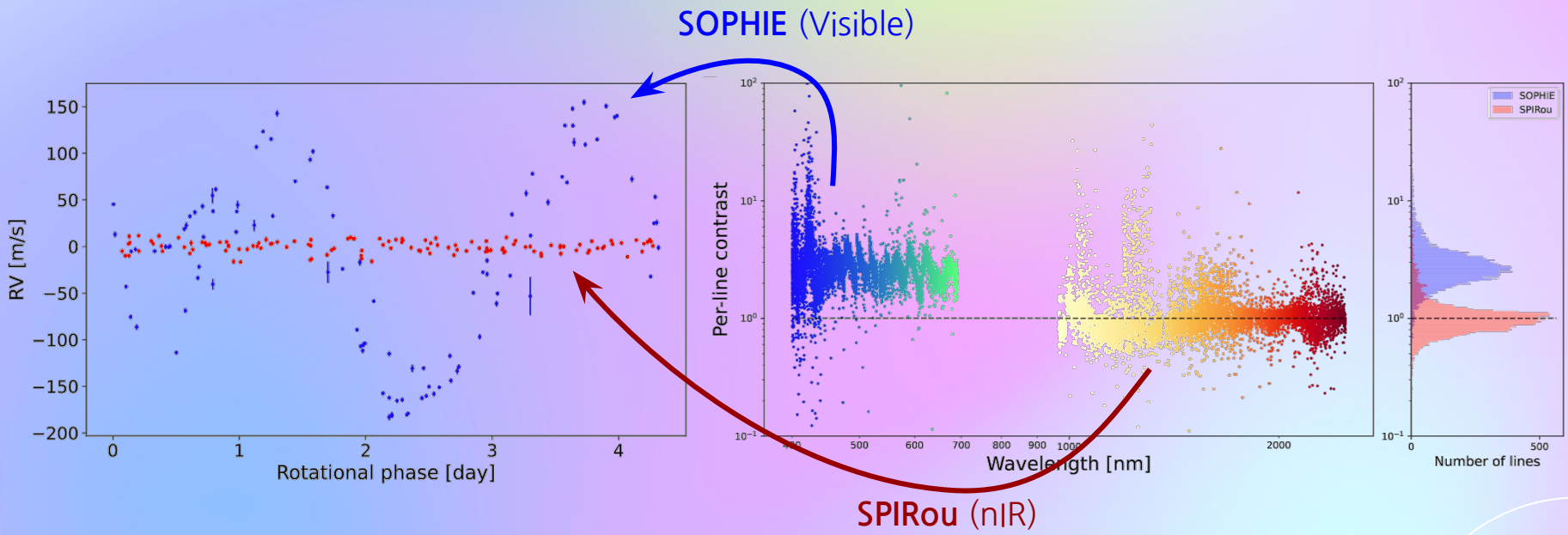
Sensitivity to **Stellar activity**





Carmona et al. (2023)

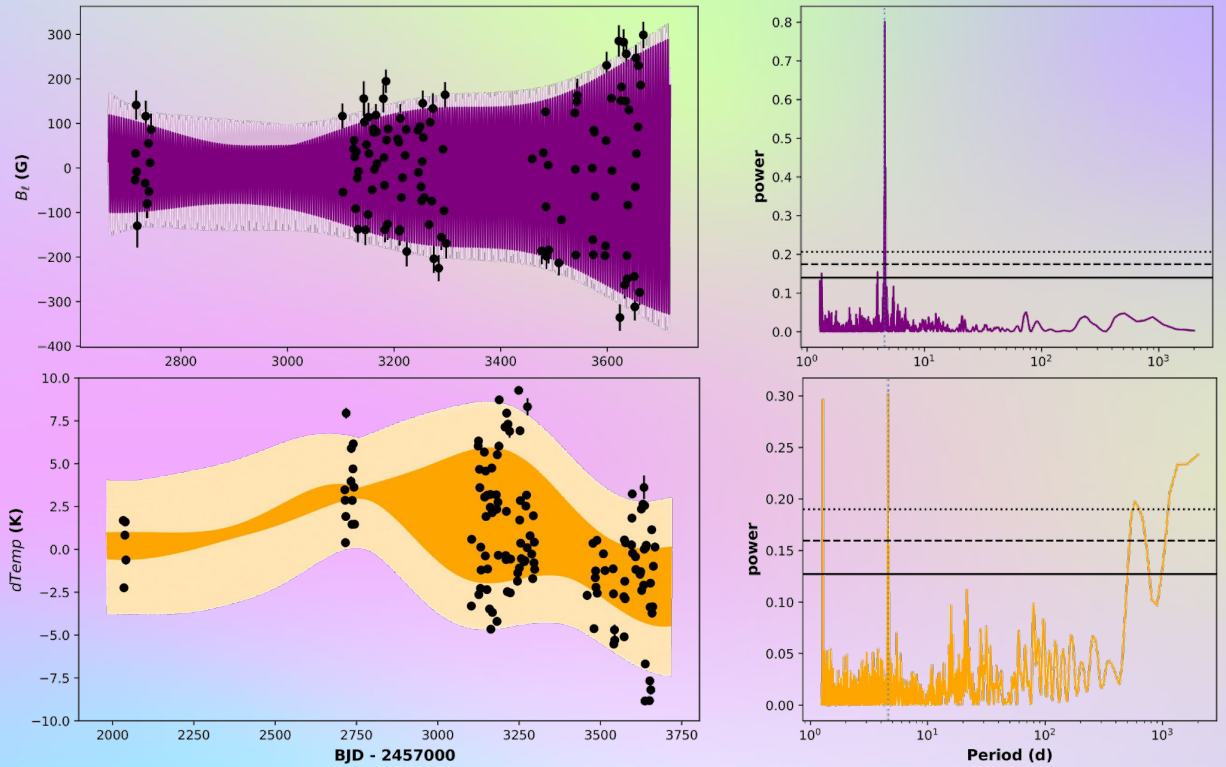
The **contrast effect**



Larue et al. (2025) analysis on **EV Lac**

Similar results on **AD Leo** (Carmona+2023), **Gl 410** (Carmona+2025), **GJ 4274** (Charpentier+2026), etc.

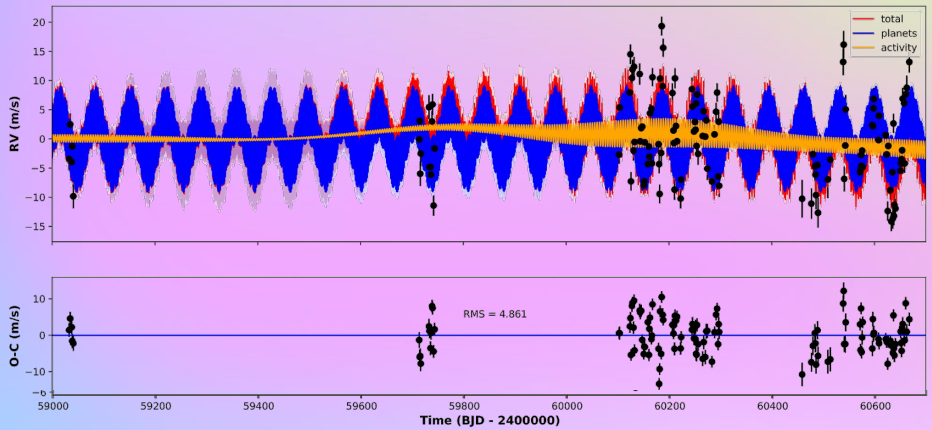
GJ 4274 , strong activity



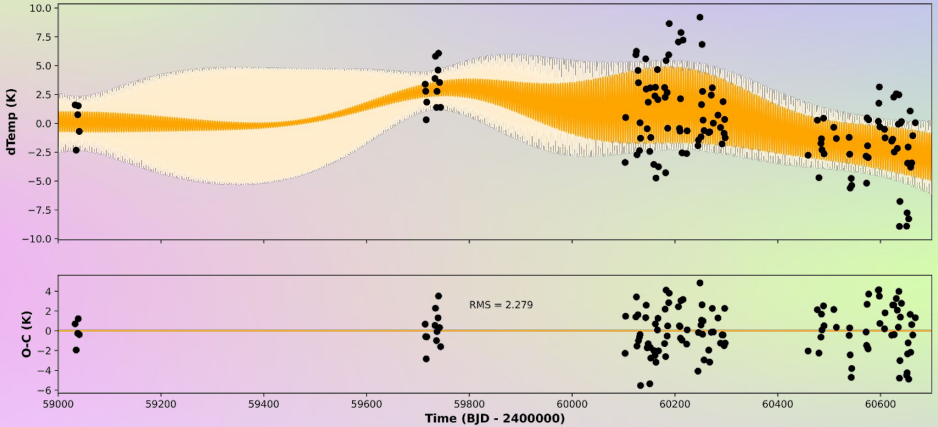
Charpentier et al. (2026)

GJ 4274 , weak RV signature

RVs

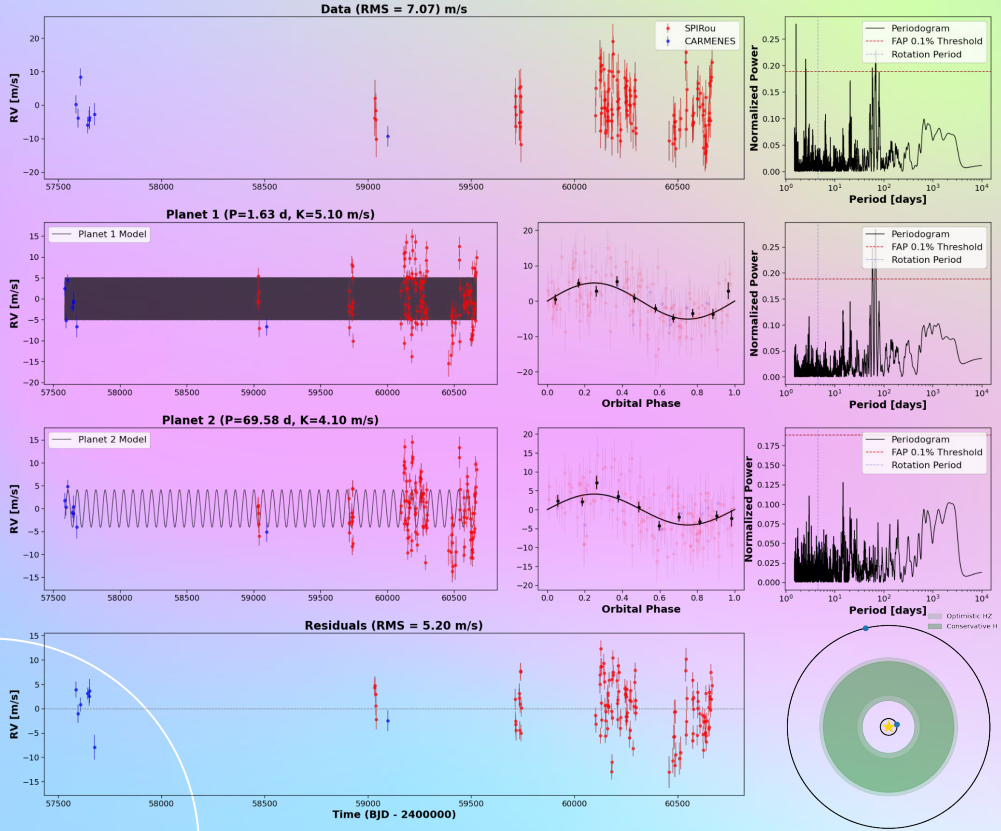


dTemp



Charpentier et al. (2026)

Two planets around GJ 4274



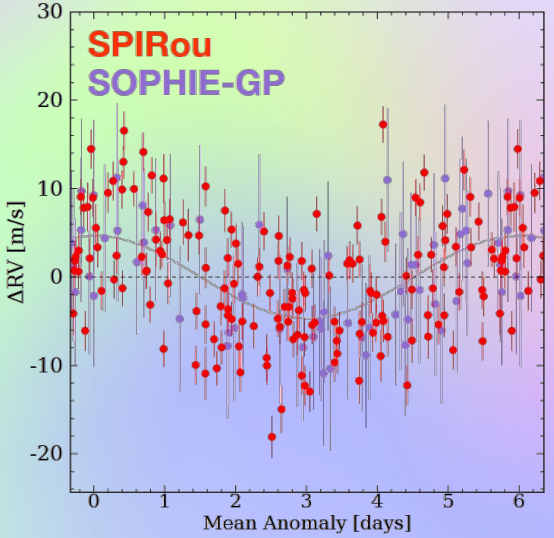
	GJ4274 b	GJ4274 c
Orbital period	1.6339 ± 0.0001 d	69.57 ± 0.36 d
Semi-amplitude	5.10 ± 0.69 m/s	4.10 ± 0.64 m/s
Eccentricity	0 (fixed)	0 (fixed)
Mass (M sin i)	2.97 ± 0.52 $M_\oplus$	8.39 ± 1.62 $M_\oplus$
Semi-major axis	0.0153 ± 0.0008 au	0.186 ± 0.010 au
Insolation	14.7 ± 1.5 $S_\oplus$	0.10 ± 0.01 $S_\oplus$

Charpentier et al. (2026)

Other **planetary detections**

Gl 410 b

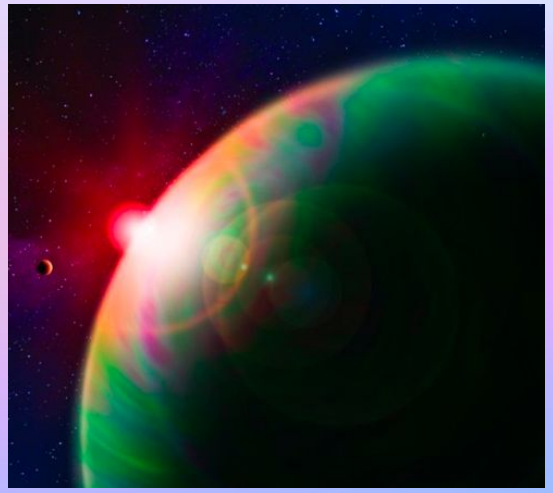
Carmona et al. (2025)



8.4 ± 1.3 $M_{\oplus}$; 6.020 ± 0.004 d
+ 2 potential candidates

Gl 725B b & c

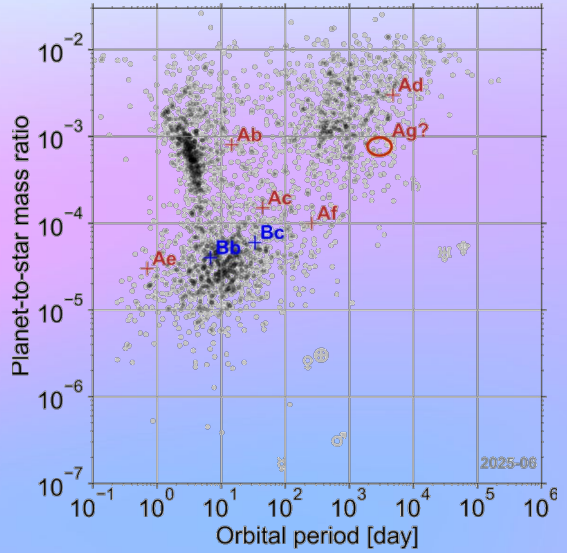
Ould-Elhkim et al. (2026)



Press release
2nd closest planet in its habitable zone

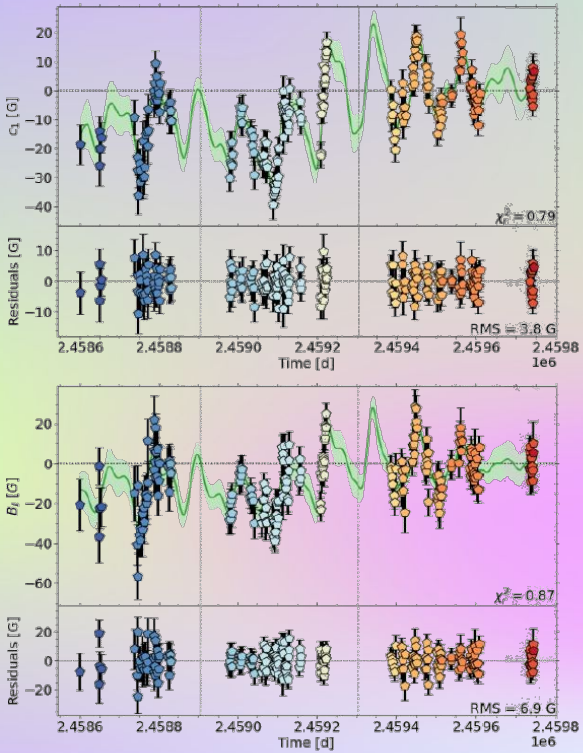
55 Cnc system revised

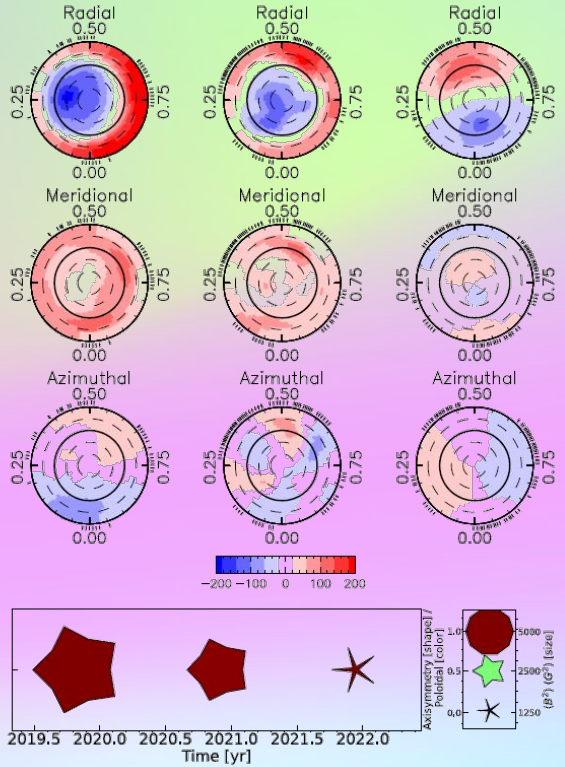
Moutou et al. (2026)



2 New planets around 55 Cnc B
1 Candidate around the magnetic cycle of 55 Cnc A (~11yrs)

Longitudinal **magnetic field**



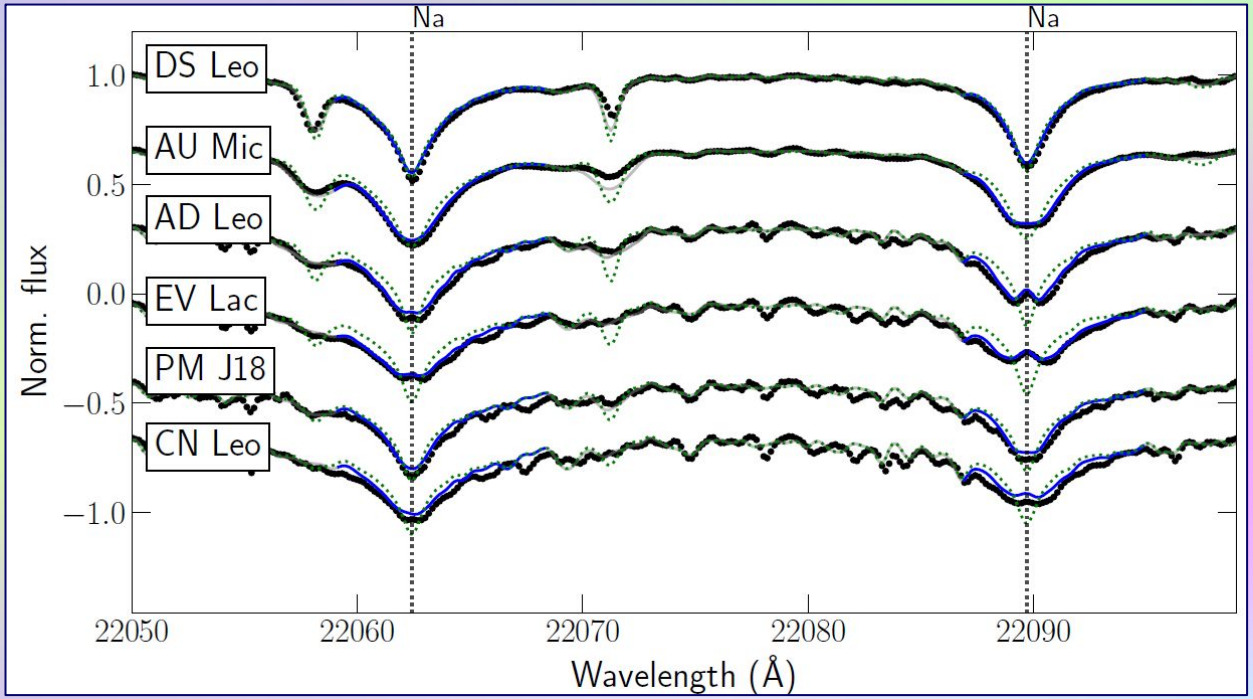


Systematic determination of the rotation period of 43 M dwarfs observed with SPIRou from BI measurements

Fouqué et al. (2023)
Donati et al. (2023)

Lehmann et al. (2024) on Gl 905

Small scale **magnetic field**



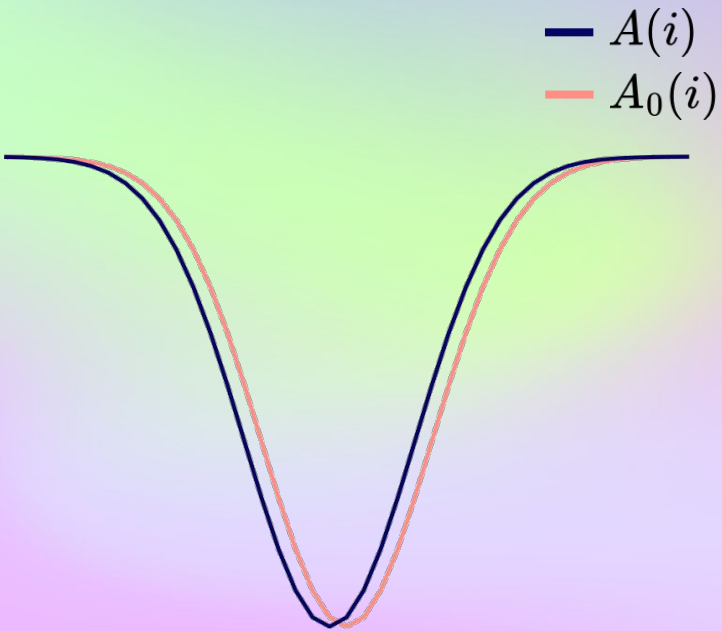
Works of **Paul Cristofari**
Since 2022

With a new fast and robust method integrated in the LBL framework **Cristofari et al. (2026)**

The LBL framework

$$A(i) - A_0(i) = \frac{\partial A_0(i)}{\partial \lambda(i)} \delta\lambda(i)$$

Bouchy's equation
Bouchy, Pepe & Queloz (2001)



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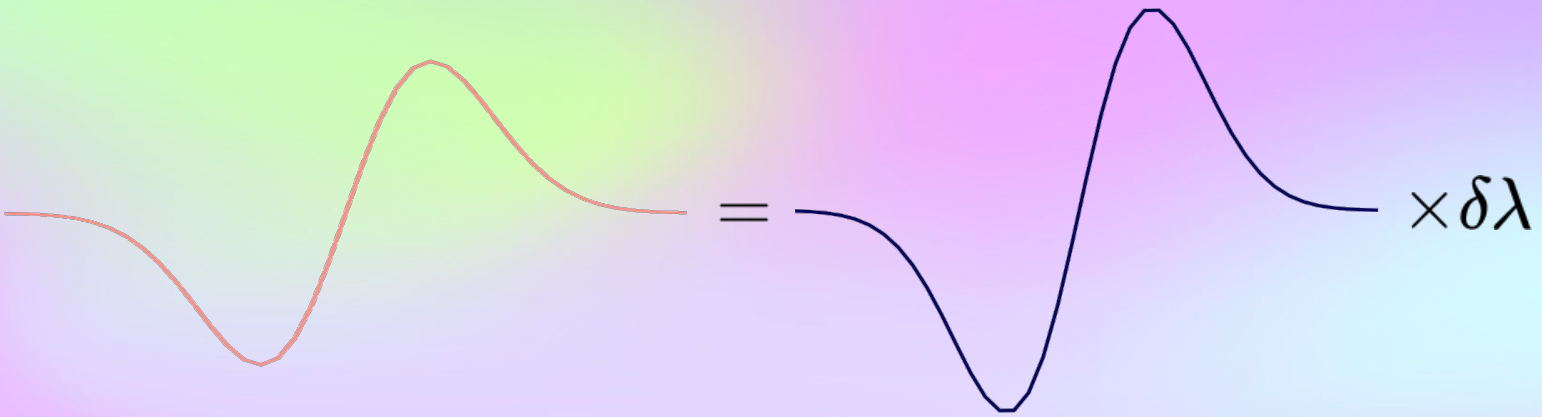
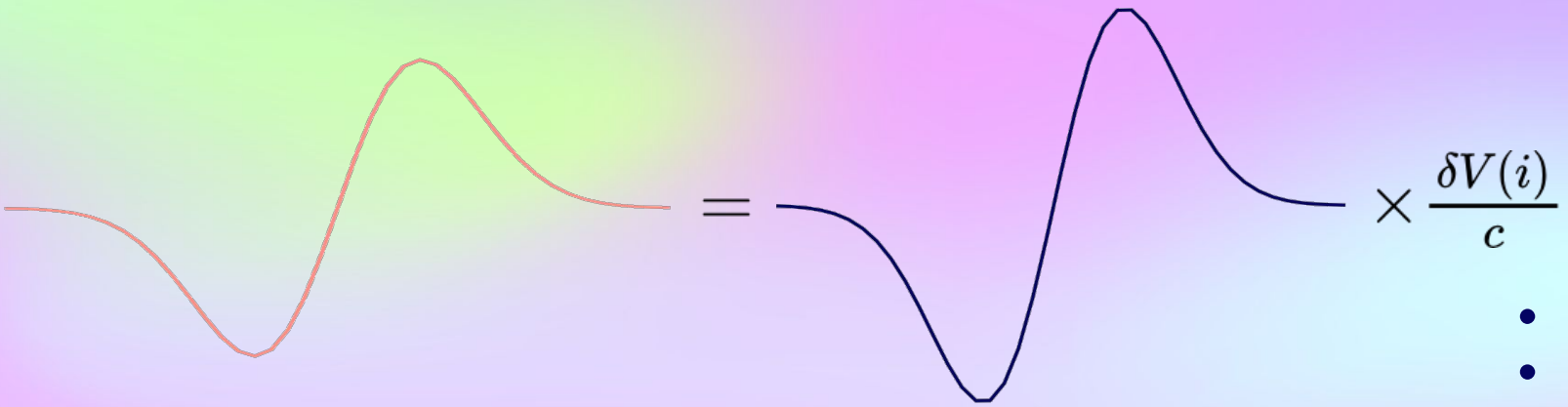


The LBL framework

$$A(i) - A_0(i) = \frac{\partial A_0(i)}{\partial \lambda(i)} \frac{\delta V(i)}{c}$$

Bouchy's equation
Bouchy, Pepe & Queloz (2001)



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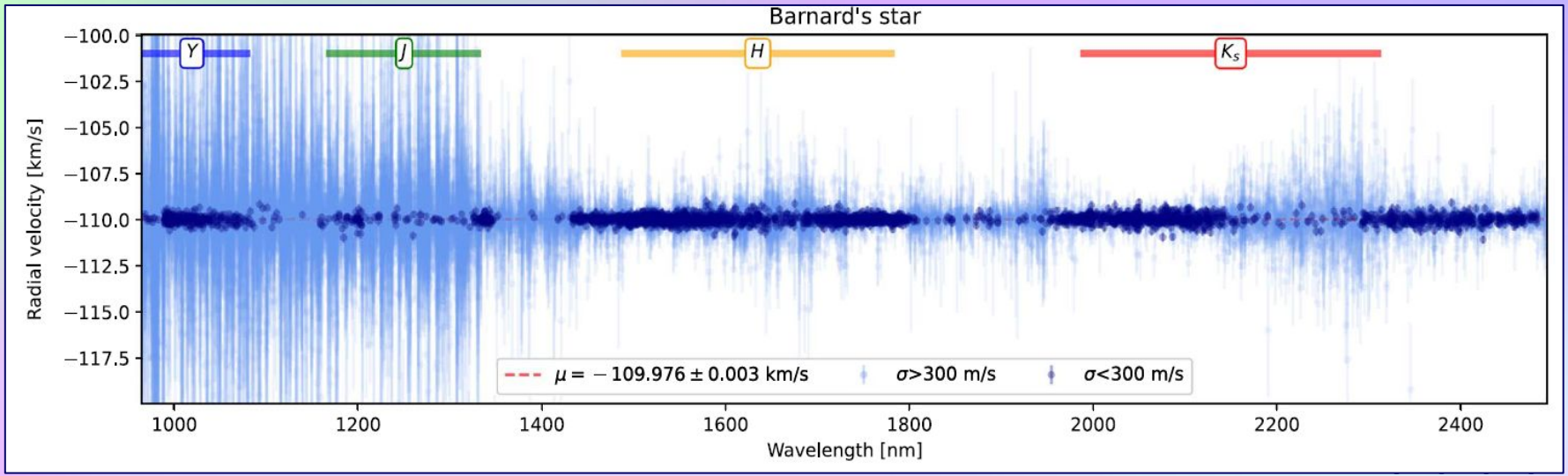
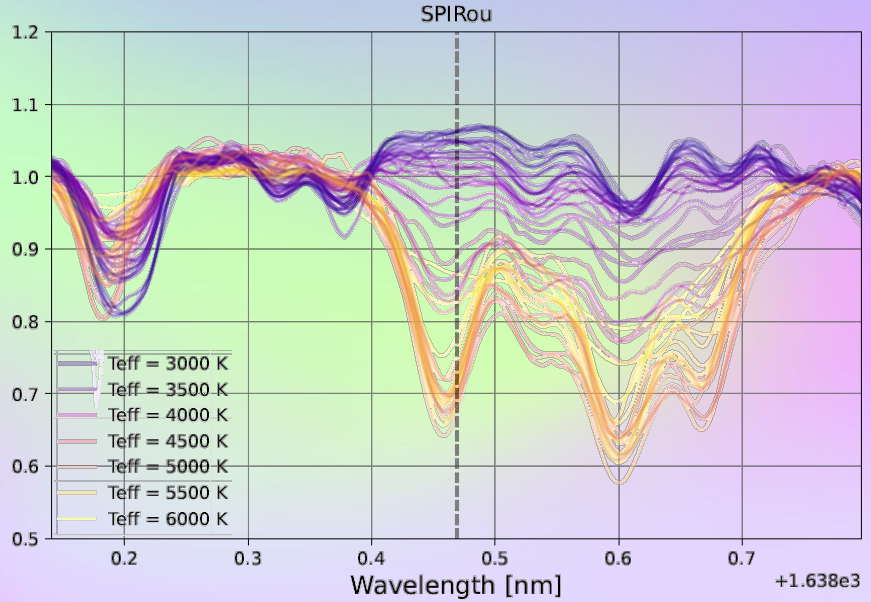


LBL - Artigau et al. (2022)

Temperature variations (*dTemp*)



$$A(i) - A_0(i) = \frac{\partial A_0(i)}{\partial \lambda(i)} \delta\lambda(i)$$

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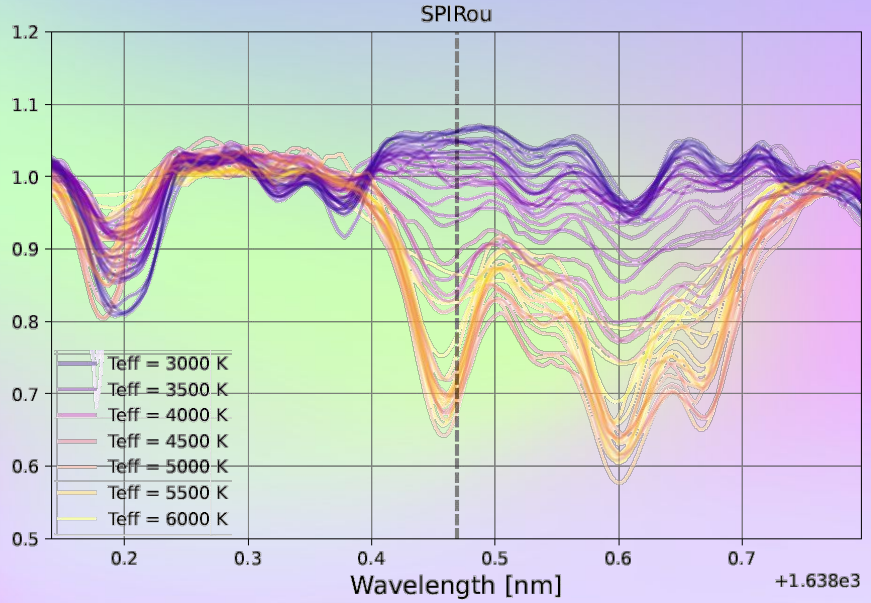
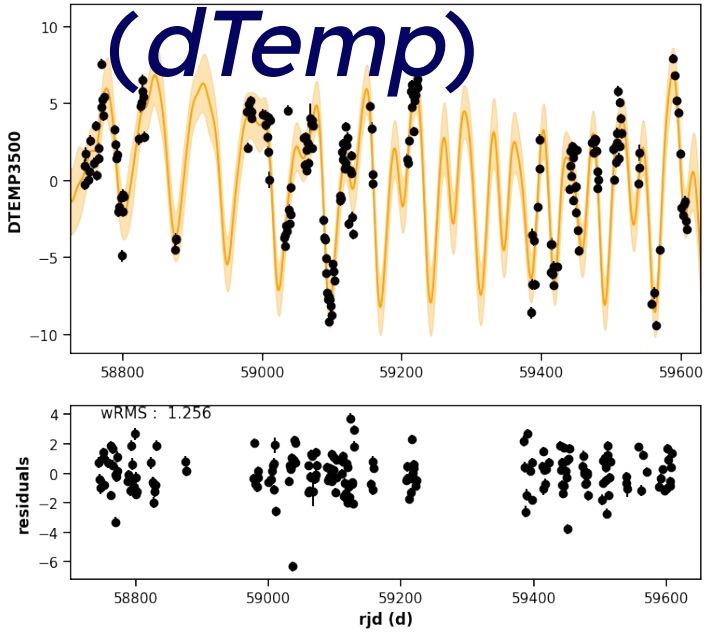
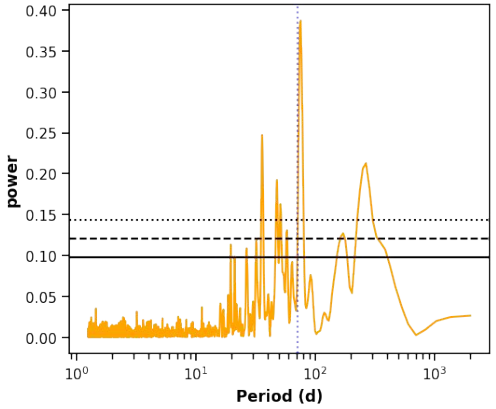


$$A(i) - A_0(i) = \frac{\partial A_0(i)}{\partial T(i)} \delta T(i)$$

Bouchy's equation projected onto a temperature gradient
Artigau et al. (2024b)

Temperature variations (*dTemp*)





GJ 4333
P_{rot} = 72.5 ± 1.5 d

Systematic determination of the rotation period of 66 M dwarfs observed with SPIRou from dTemp measurements

Charpentier et al. (in prep)

Ad break

My **resume**

https://paul-charpentier.github.io/star_rotation/

Stellar Rotation Period Database

Search star

Gl 205

Search

Gl 205
Prot = 34.3 ± 0.4 d
Ref: Fouqué et al. 2023

Gl 205
Prot = 34.4 +0.5 -0.4 d
Ref: Cortés-Zuleta et al. 2023

Gl 205
Prot = 34.58 ± 0.46 d
Ref: Donati et al. 2023

Gl 205
Prot = 33.8 ± 0.6 d
Ref: Díez Alonso et al. 2023

Gl 205
Prot = 35 ± 0.1 d
Ref: Suárez Mascareño et al. 2015

Gl 205
Prot = 33.4 ± 0.1 d
Ref: Suárez Mascareño et al. 2016

Gl 205
Prot = 33.63 ± 0.37 d
Ref: Hebrard et al. 2016

Gl 205
Prot = 34.8 ± 1.3 d
Ref: Suárez Mascareño et al. 2017

Gl 205
Prot = 33.61 ± null d
Ref: Kiraga & Stepien 2007

Gl 205
Prot = 32.8 ± null d

Take away message

SPIRou is still striking...

8 (+5) new planet detection this year only counting published results.

thanks to **the LBL framework** ,

The individualisation of the contribution of each lines to RV, activity indicators, etc. allows powerful statistical/machine learning analysis that exploit the entire spectral richness.

... and **will continue** to,

With the new Amakihi large program. 1000 CFHT nights between 2027 and 2031.

and **largely contribute** to the **recent success** of **new-gen instruments**

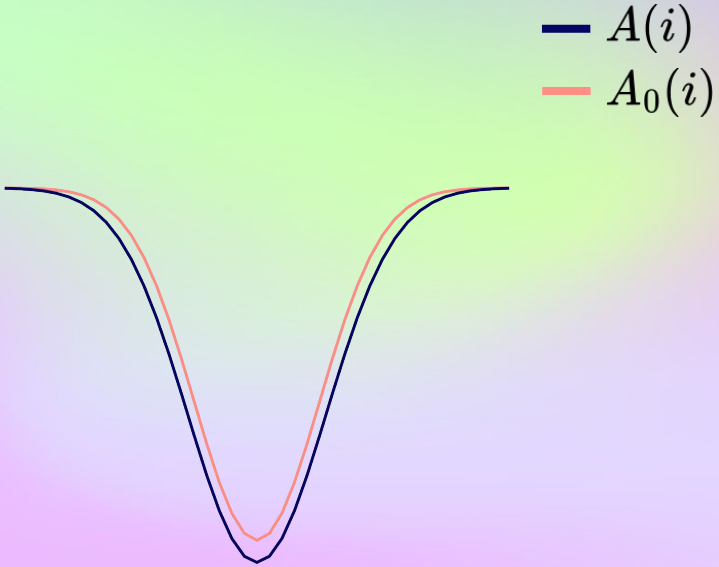
SPIRou walked so that NIRPS could run

Appendix

Activity indicators : differential Line Width (*dLW*)

$$A(i) - A_0(i) = \frac{\partial A_0(i)}{\partial \lambda(i)} \delta\lambda(i) + \frac{\partial^2 A_0(i)}{\partial \lambda(i)^2} \frac{dLW(i)}{c^2} \lambda(i)^2$$

Extended Bouchy's equation
Artigau et al. (2022)



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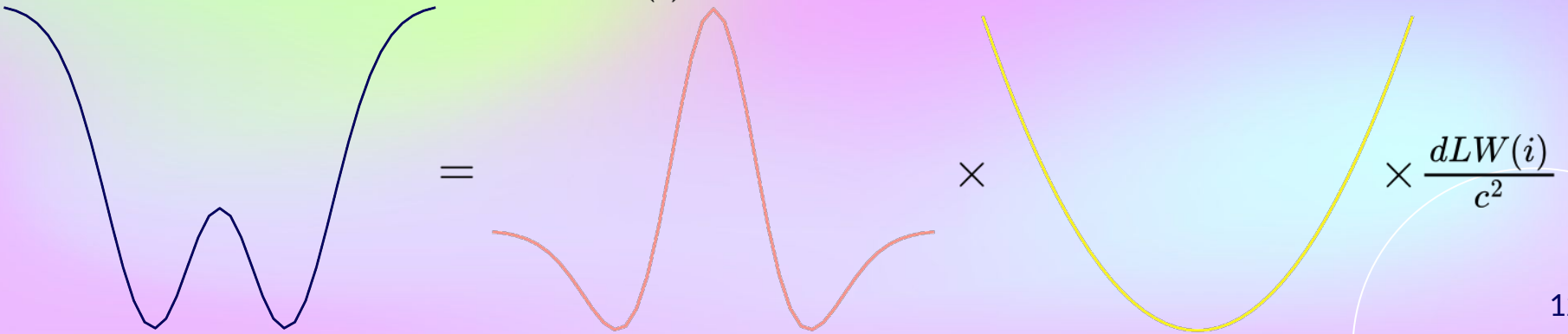
Extended Bouchy's equation
Artigau et al. (2022)

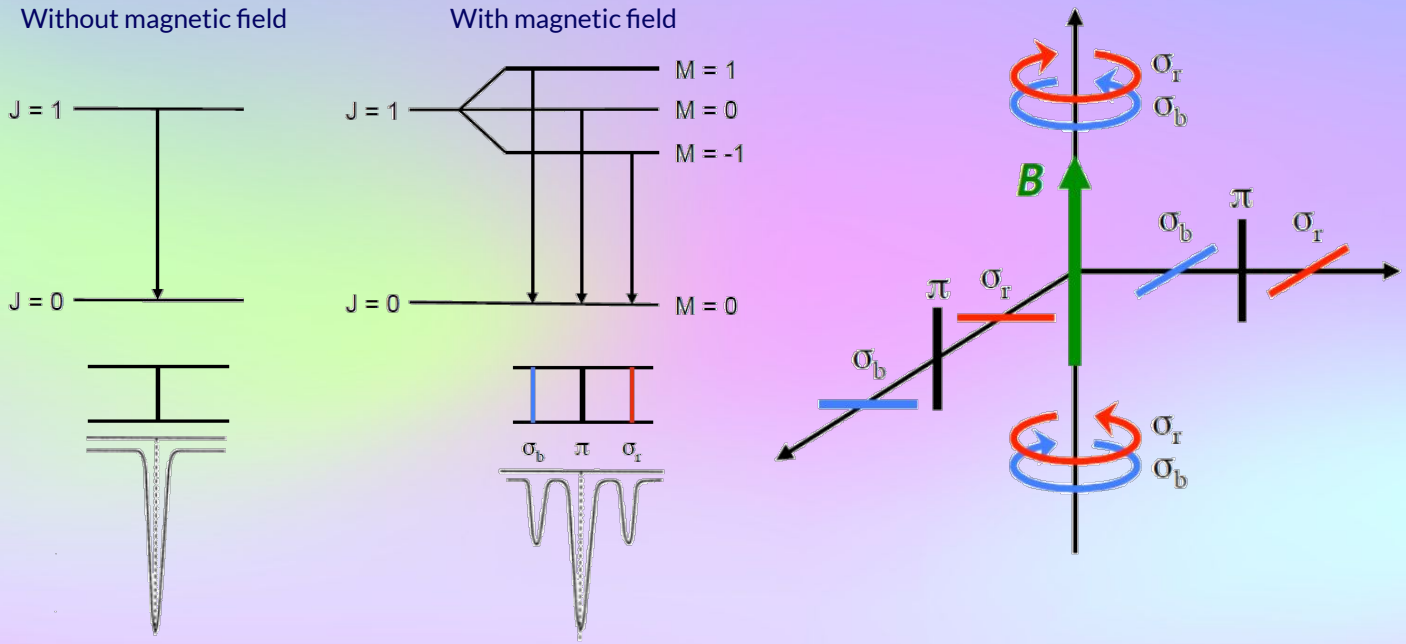
$A(i) - A_0(i)$

$\frac{\partial^2 A_0(i)}{\partial \lambda(i)^2}$

$\lambda(i)^2$

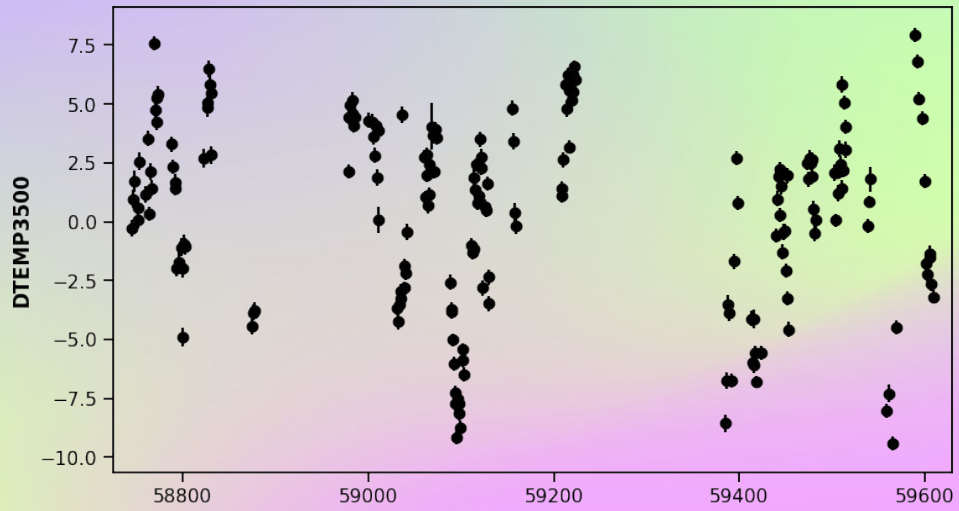


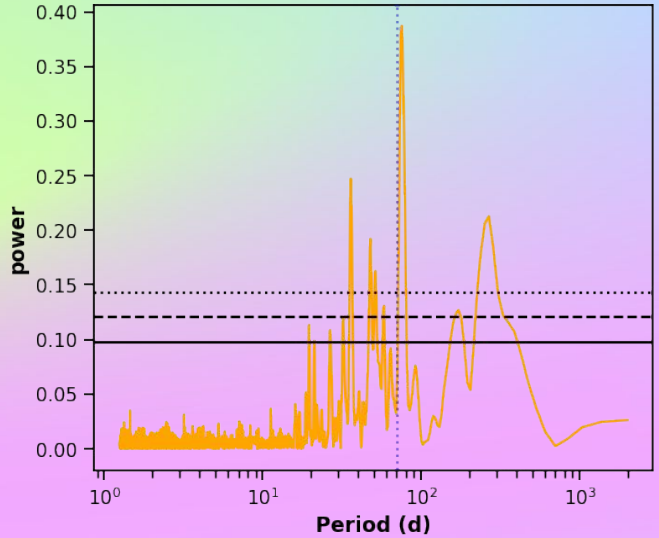
Monitor the magnetic field using spectropolarimetry



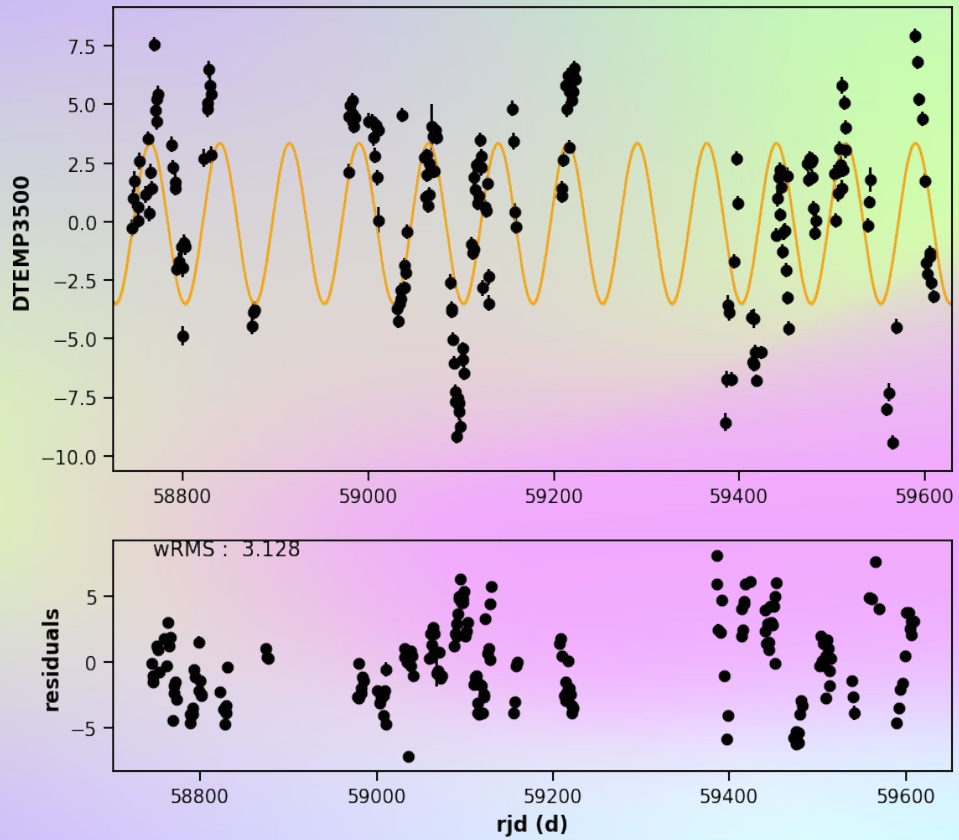
The Zeeman effect

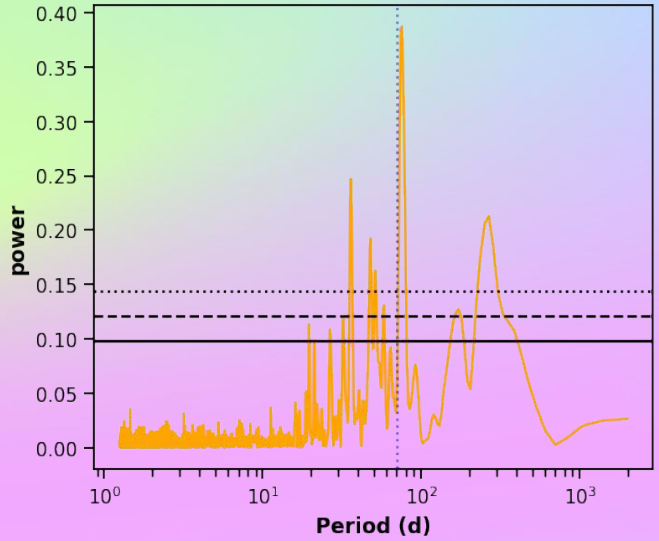
GJ4333 data


DTEMP3500
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10.0
58800
59000
59200
59400
59600

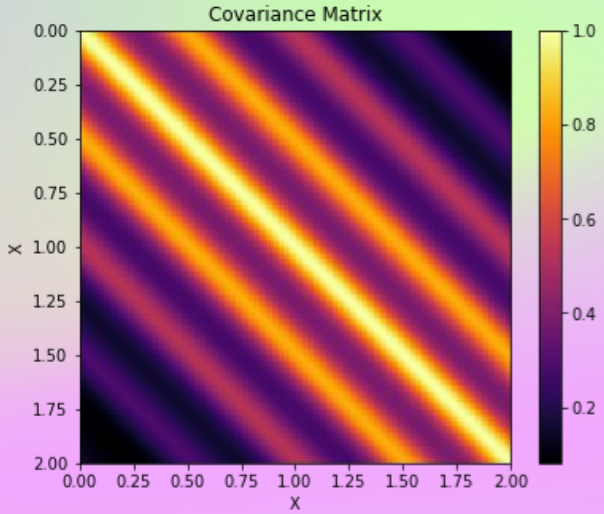

power
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
10^0
10^1
10^2
10^3
Period (d)

GJ4333 Sinusoidal fit



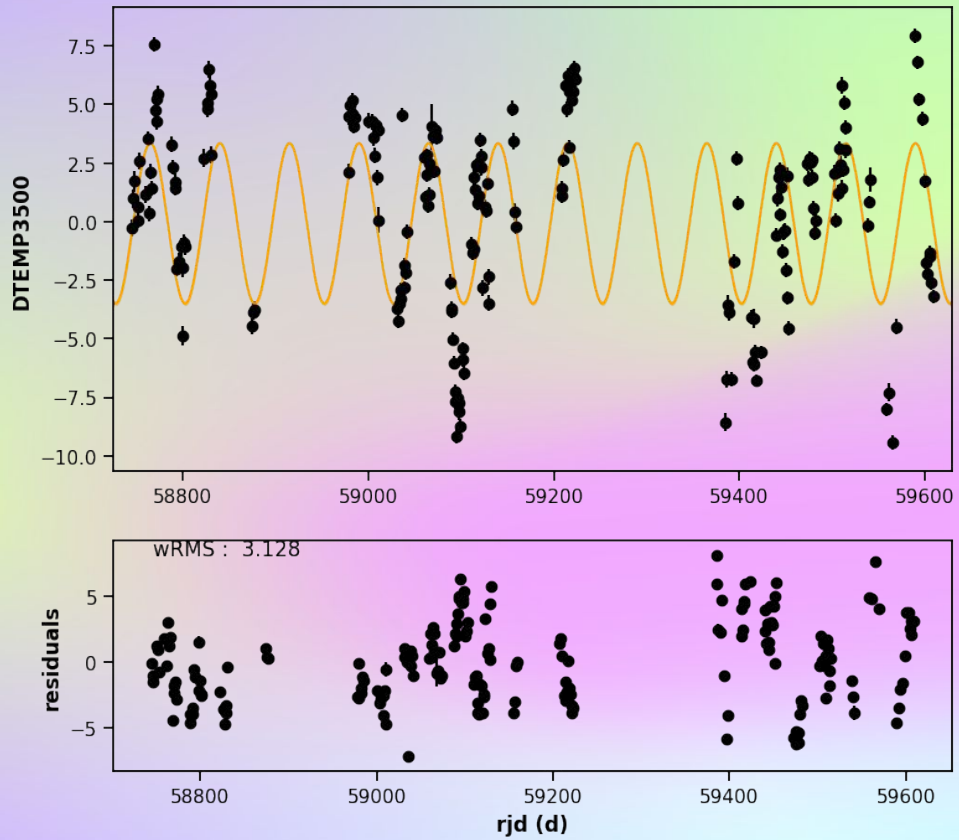


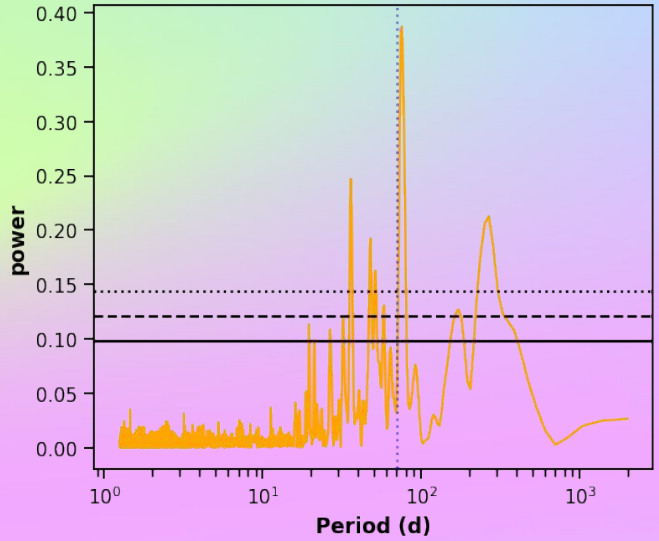
Quasi Periodic **Gaussian Process**



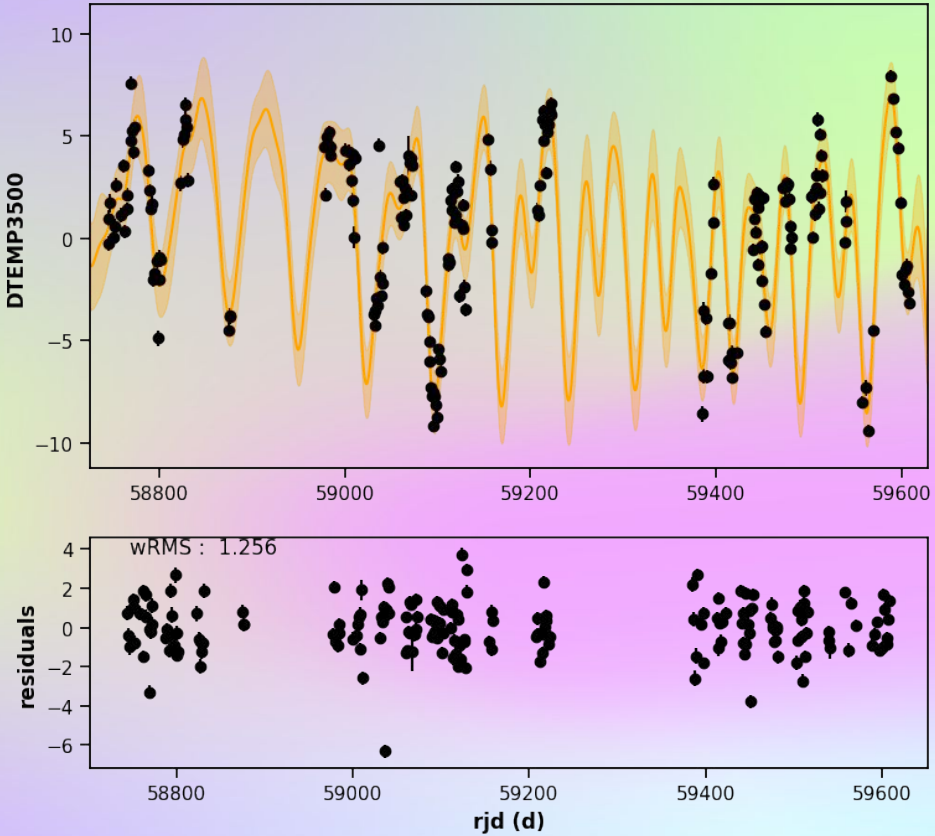
$$k(t_i, t_j) = a^2 \exp\left(-\frac{\sin^2\left(\frac{\pi \Delta t_{i,j}}{P_{rot}}\right)}{2\lambda_p^2} - \frac{\Delta t_{i,j}}{2\lambda_e^2}\right) + Jitter$$

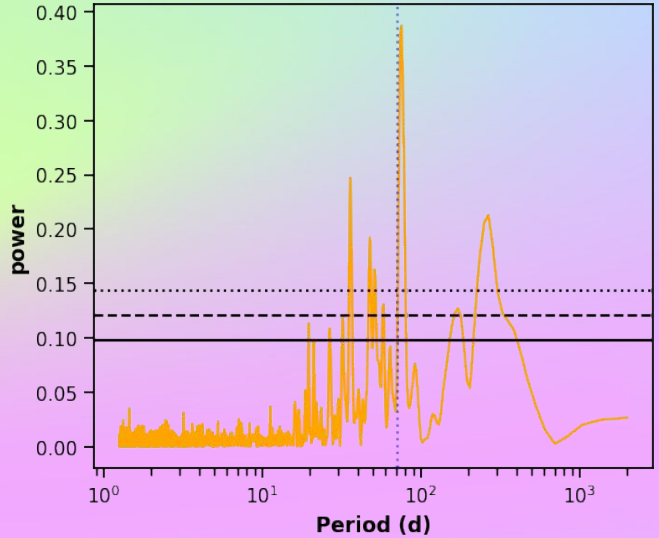
GJ4333 Sinusoidal fit





GJ4333 GP regression





$P_{rot} = 72.2^{+0.8}_{-0.8} d$

$a = 4.56^{+1.17}_{-0.78} K$

$\lambda_e = 160 \pm 32 d$ $\lambda_p = 0.87^{+0.16}_{-0.13}$

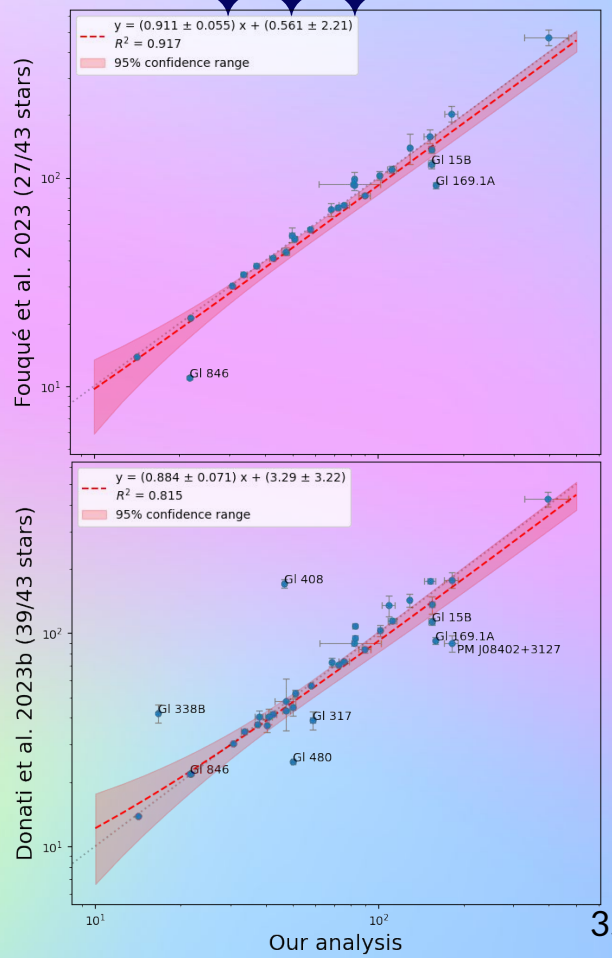
$Jitter = 1.37 \pm 0.08 K$

Results on 66 M dwarfs

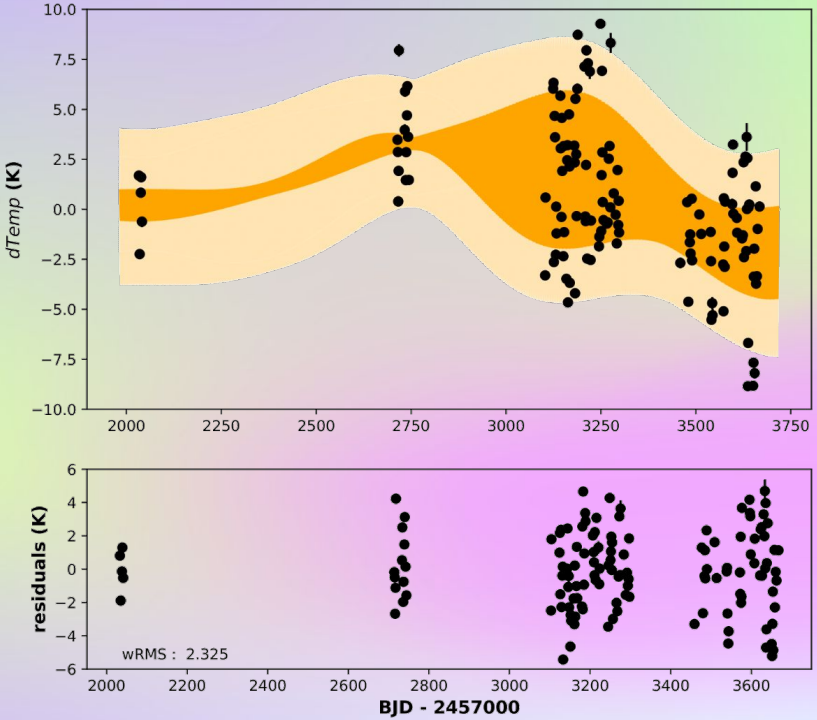
52 rotation period constrained

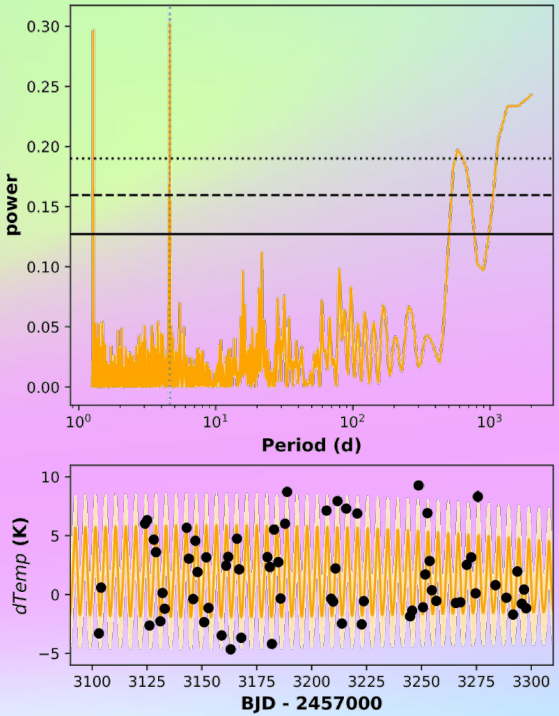
In good agreement with the literature

- ➔ In particular, with **B_ℓ studies** (Fouqué+2023; Donati+2023b).
- ➔ Only 7 in conflict with previous studies
- ➔ Complementarity with other activity indicators (B_ℓ, <B>)



GJ4274 dTemp



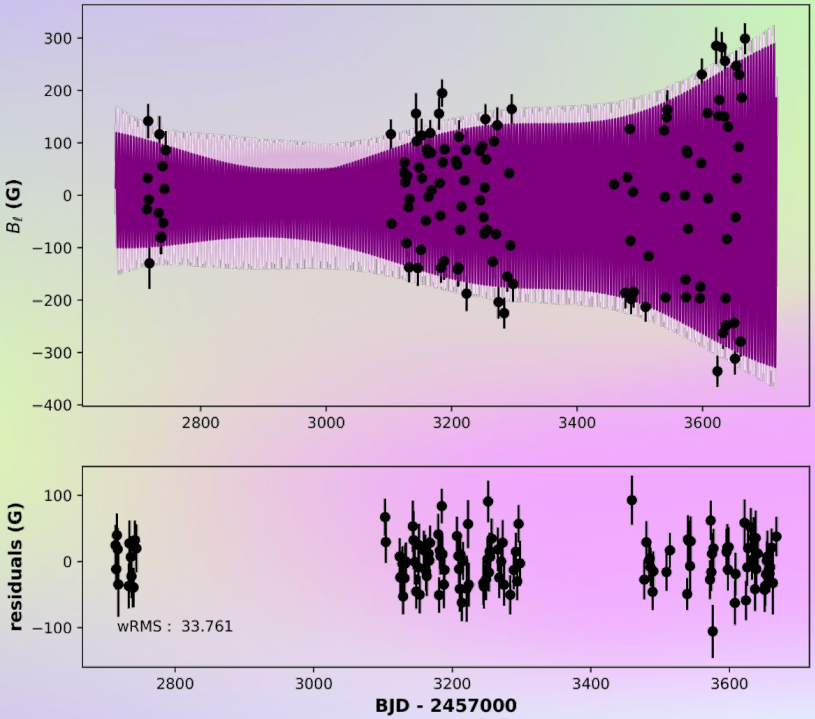


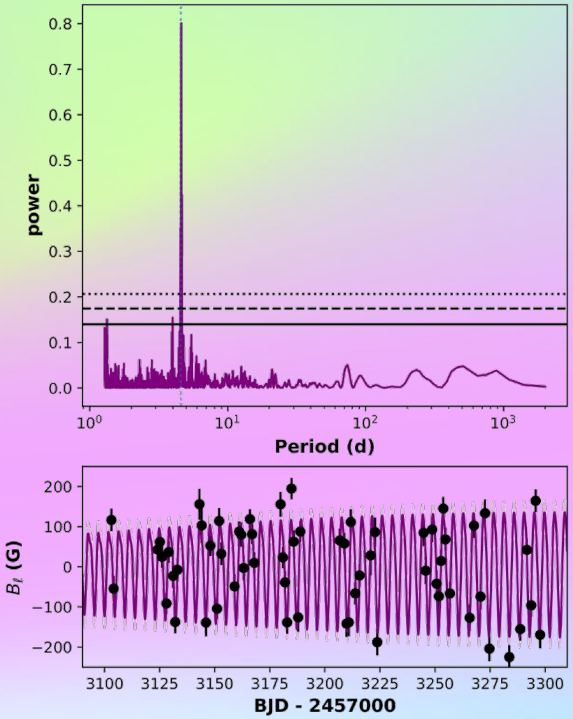
$$P_{rot} = 4.597^{+0.014}_{-0.011} d$$

Literature :

4.591d (Newton+2018)
4.57d (Shan+2024)

GJ4274 B_ℓ

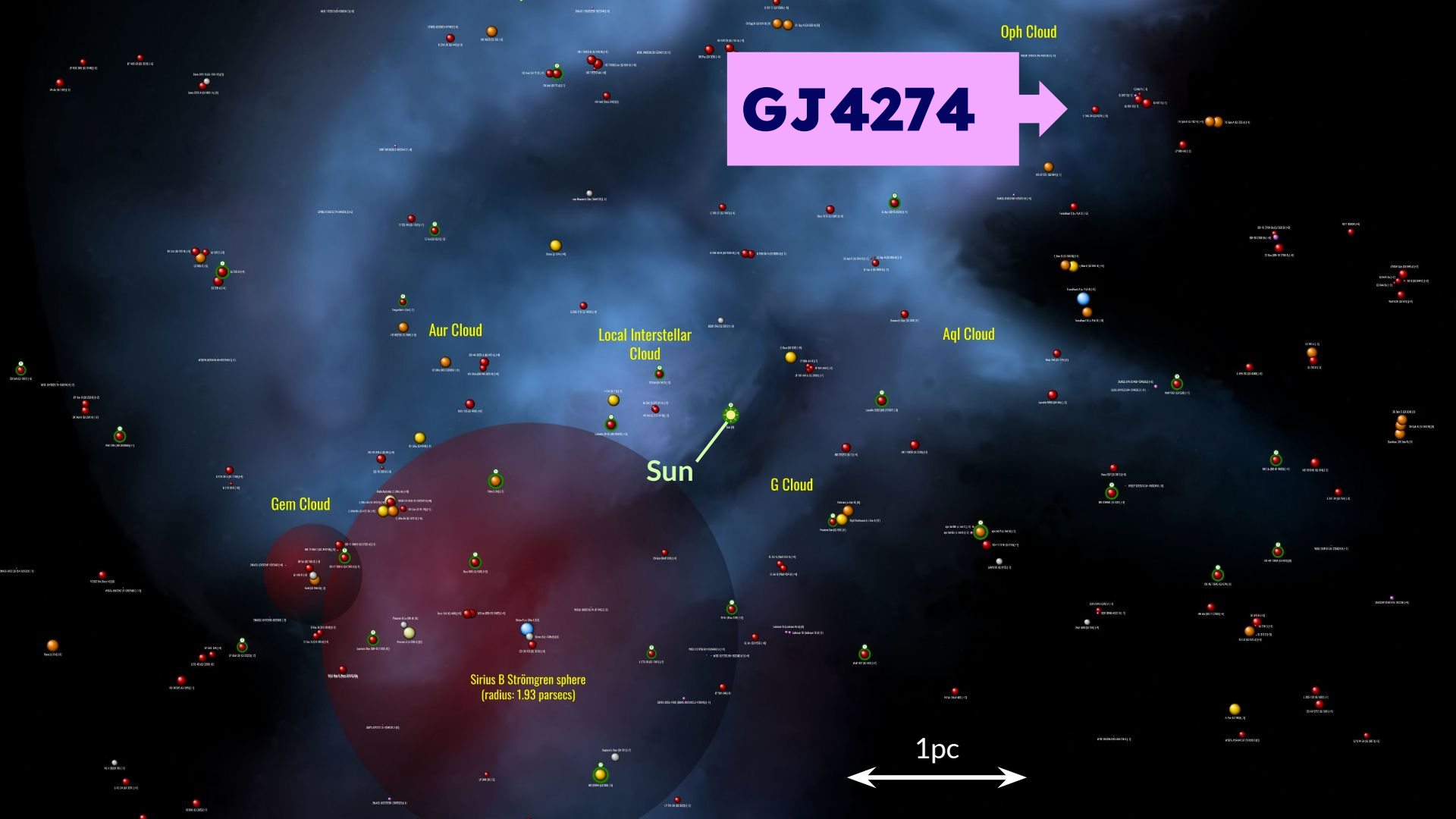




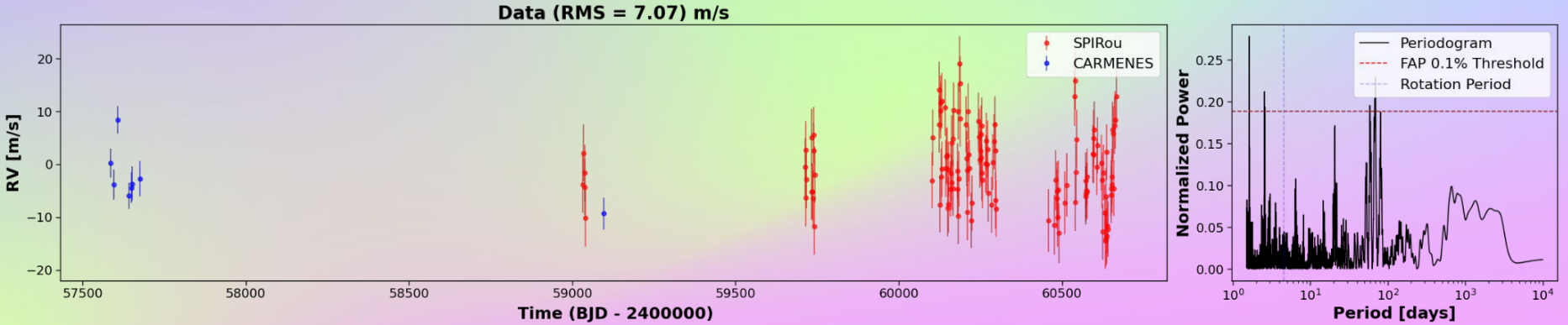
$$P_{rot} = 4.600^{+0.011}_{-0.006} d$$

Literature :

4.591d (Newton+2018)
4.57d (Shan+2024)


Oph Cloud
GJ4274
Aur Cloud
Local Interstellar Cloud
Aql Cloud
Sun
G Cloud
Gem Cloud
Sirius B Strömgren sphere (radius: 1.93 parsecs)
1pc

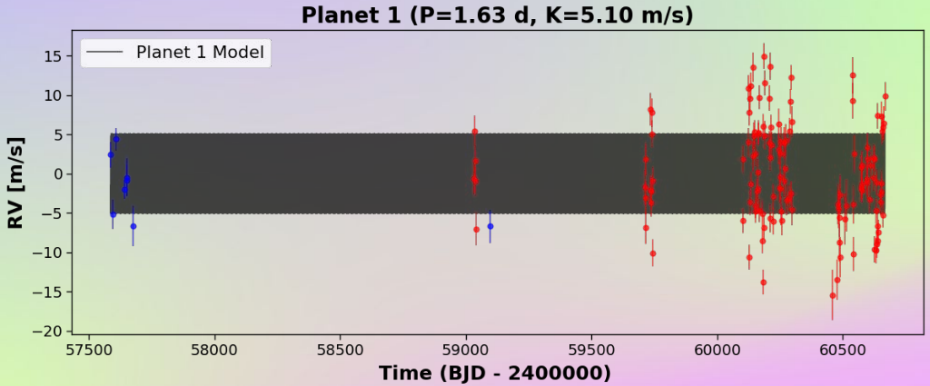
RV data

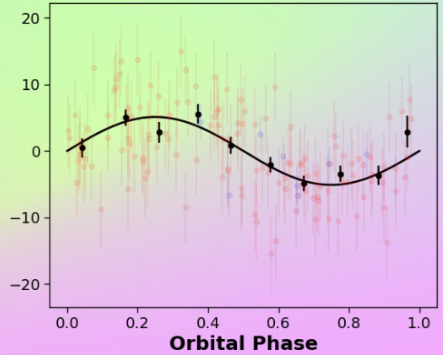


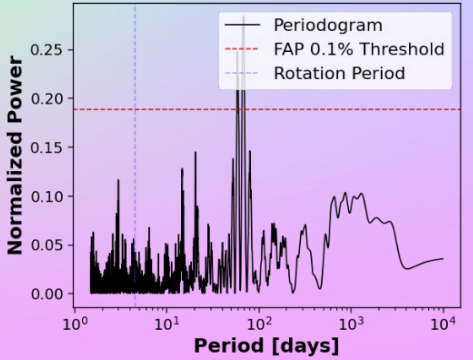
Significative signals :

- **1.634 d** logFAP = -14.9
- **69.6 d** logFAP = -13.6
- **2.560 d** logFAP = -9.5

RV data



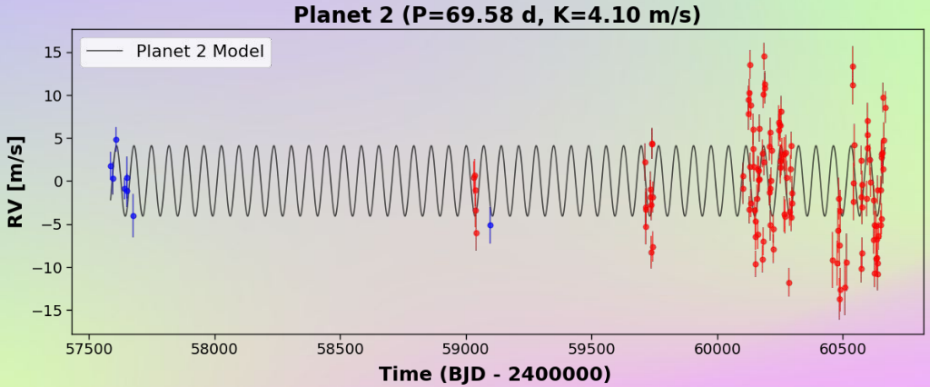


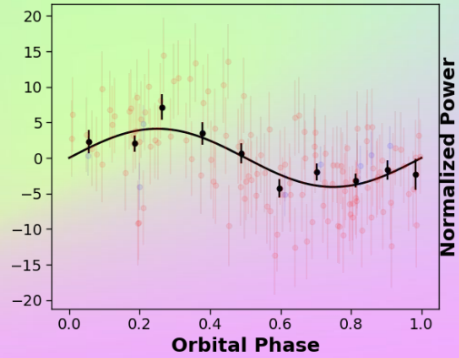


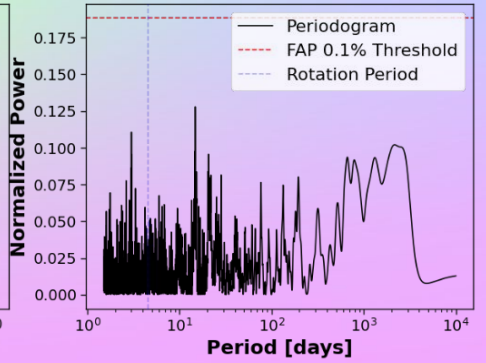
Significative signals :

- **69.2 d** logFAP = -15.0
- **58.9 d** logFAP = -11.8

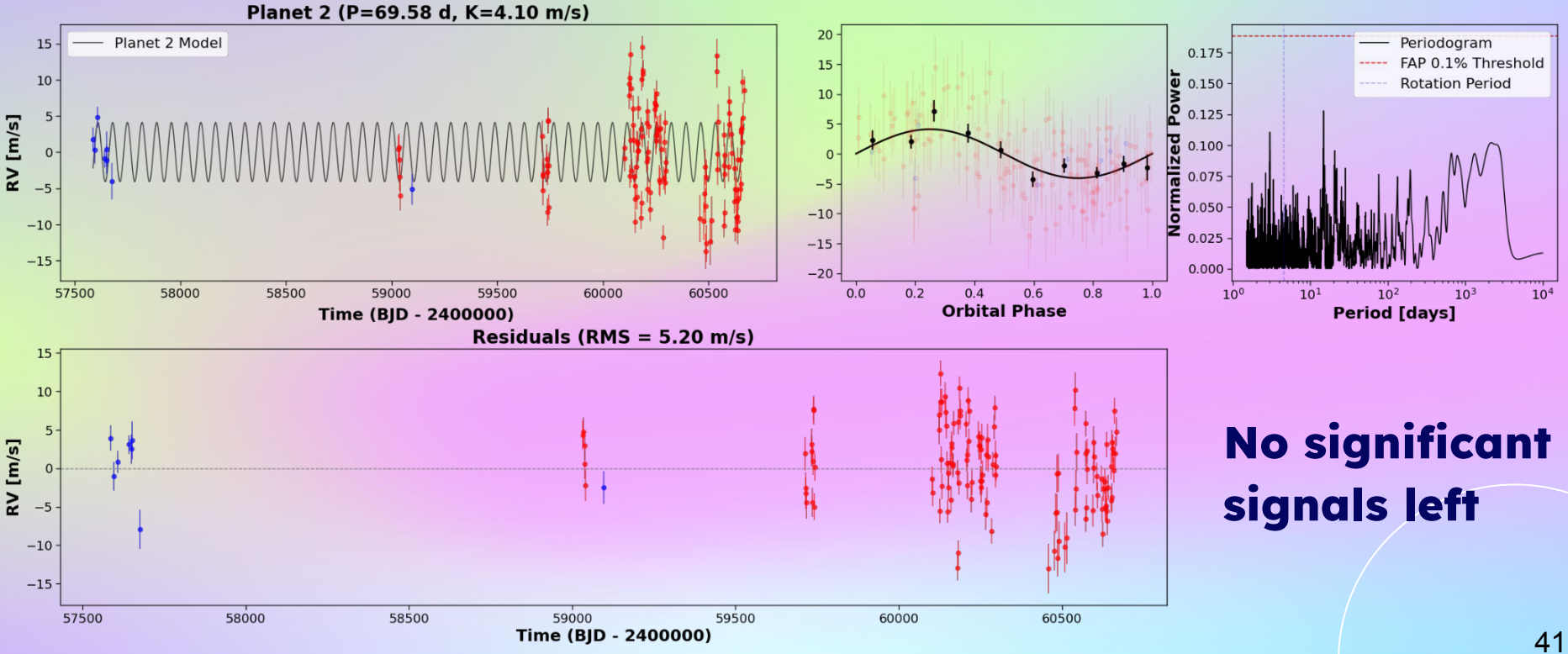
RV data


Planet 2 (P=69.58 d, K=4.10 m/s)
Planet 2 Model
RV [m/s]
Time (BJD - 2400000)


Orbital Phase


Periodogram
FAP 0.1% Threshold
Rotation Period
Normalized Power
Period [days]

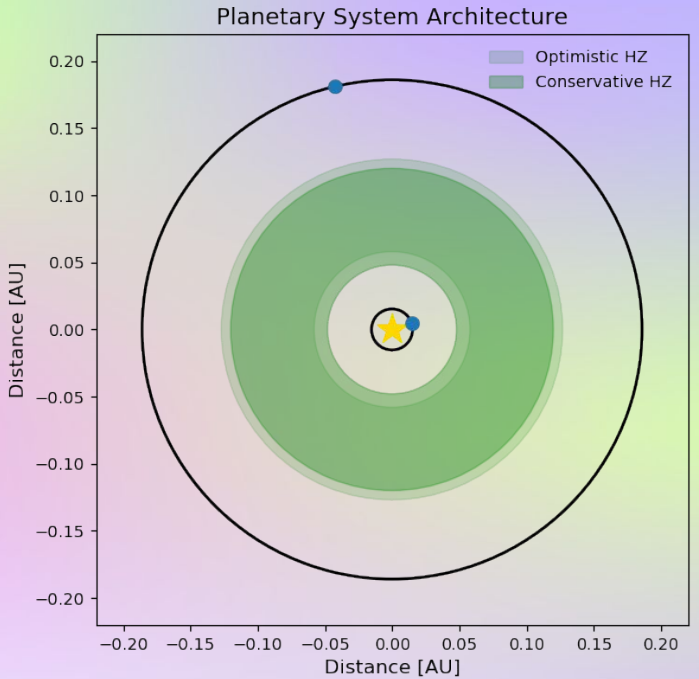
RV data



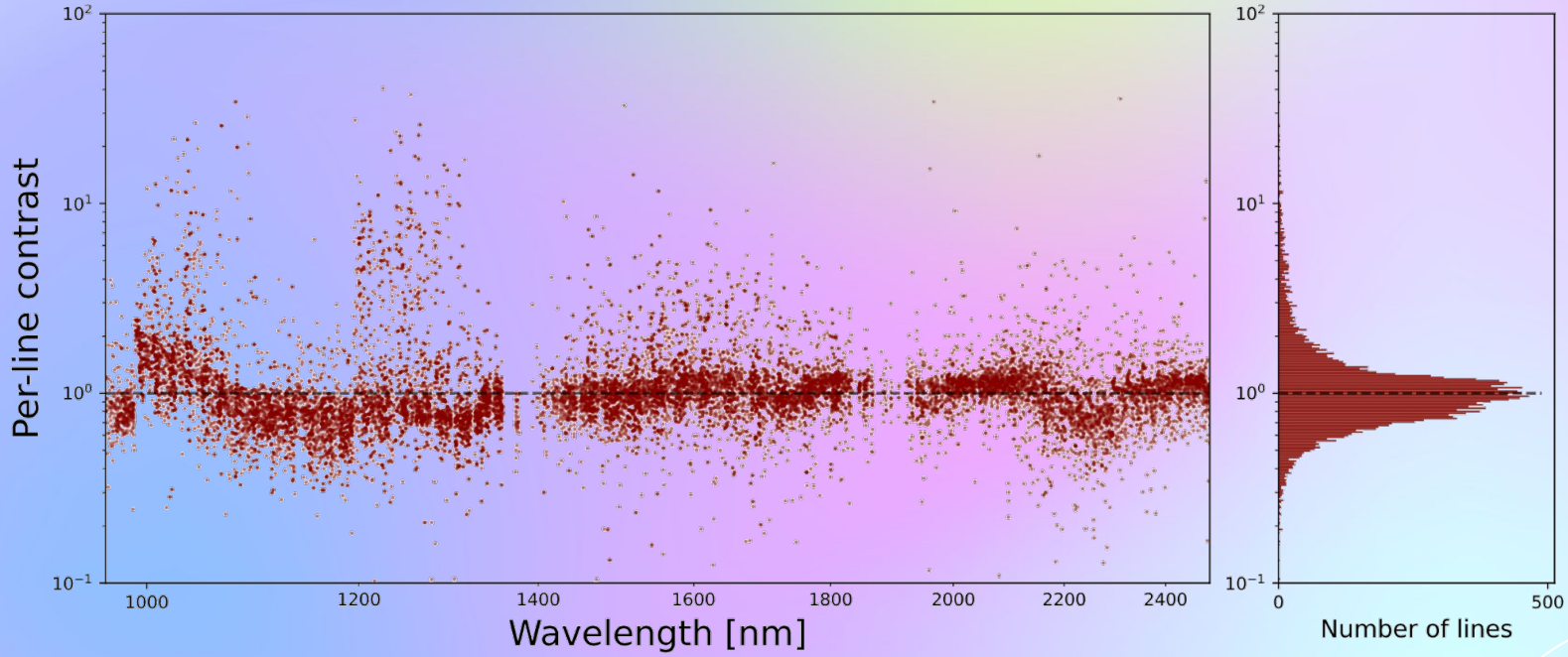
No significant signals left

Planetary parameters

	GJ4274 b	GJ4274 c
Orbital period	1.6339 ± 0.0001 d	69.57 ± 0.36 d
Semi-amplitude	5.10 ± 0.69 m/s	4.10 ± 0.64 m/s
Eccentricity	0 (fixed)	0 (fixed)
Mass (M sin i)	2.97 ± 0.52 $M_\oplus$	8.39 ± 1.62 $M_\oplus$
Semi-major axis	0.0153 ± 0.0008 au	0.186 ± 0.010 au
Insolation	14.7 ± 1.5 $S_\oplus$	0.10 ± 0.01 $S_\oplus$



The **contrast effect** (Larue+2025)



… on GJ4274

2 planets

orbiting circularly around GJ4274

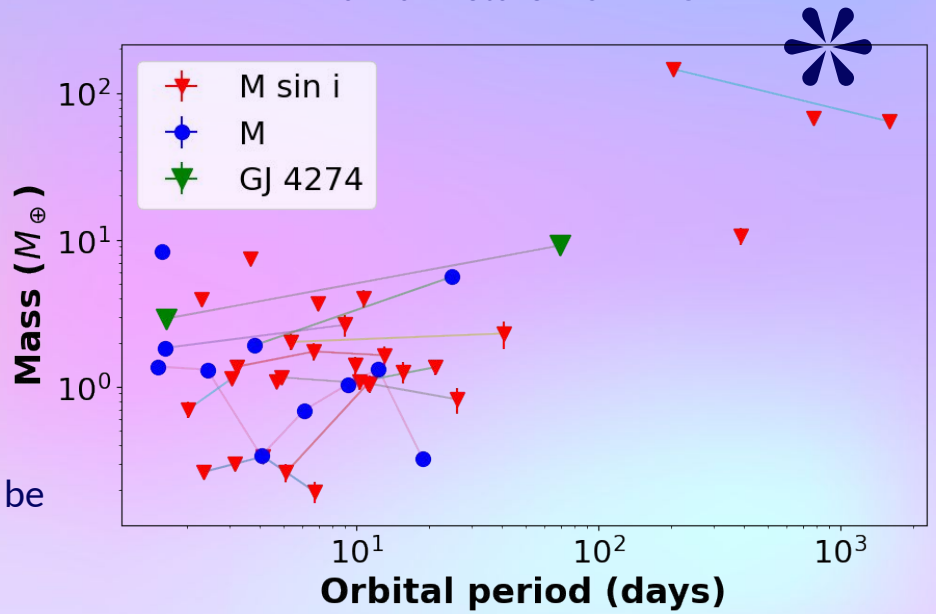
No activity in RV

Thanks to contrast effects in IR

A small light on our neighborhood

which enrich our understanding of how the worlds around us come to be

All known planets within **15pc** around stars < **0.2 M⊙**



… on GJ4274

2 planets

orbiting circularly around GJ4274

No activity in RV

Thanks to contrast effects in IR

A small light on our neighborhood

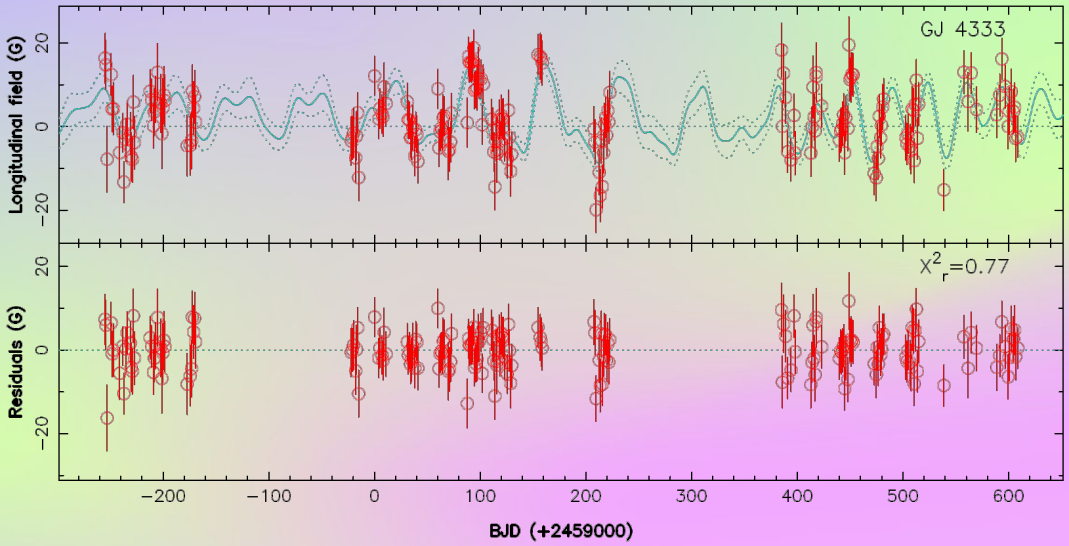
which enrich our understanding of how the worlds around us come to be

Proximity

An opportunity for further observations

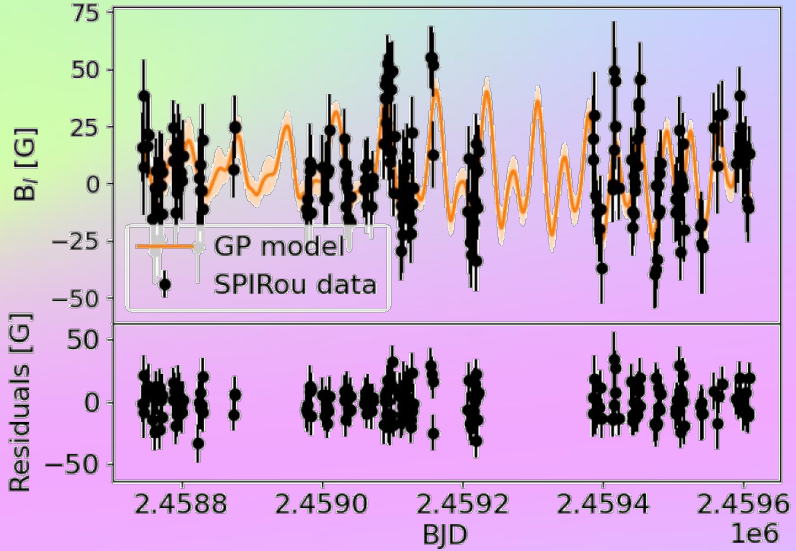
ANDES

GJ4333 B_ℓ analysis



Donati et al. (2023b)

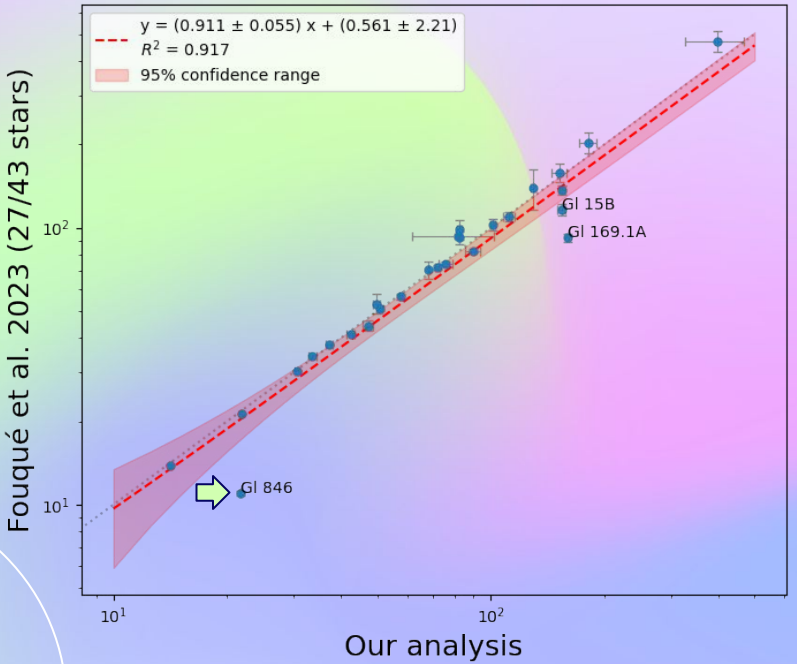
$$P_{rot} = 71.0 \pm 1.5d$$

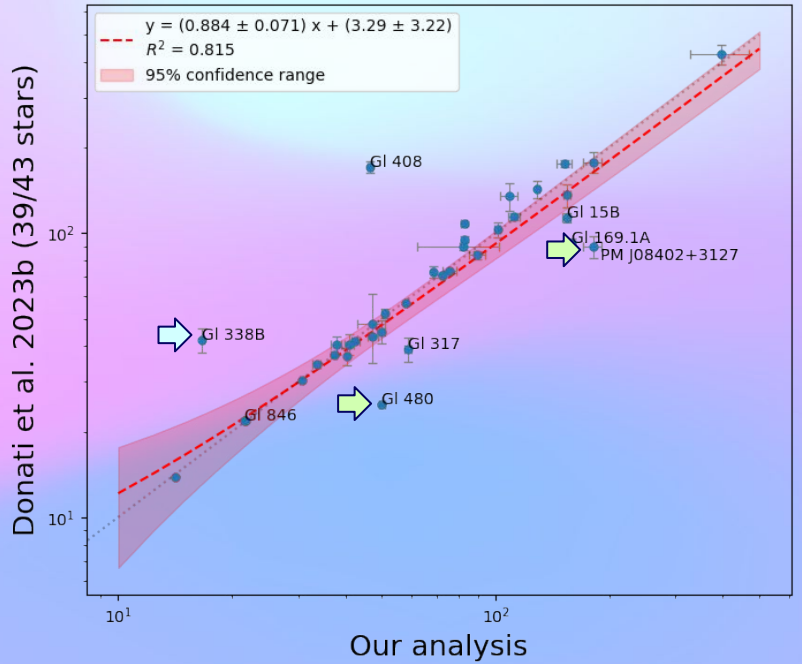


Fouqué et al. (2023)

$$P_{rot} = 72.0 \pm 1.0d$$

Comparison with B_ℓ analysis

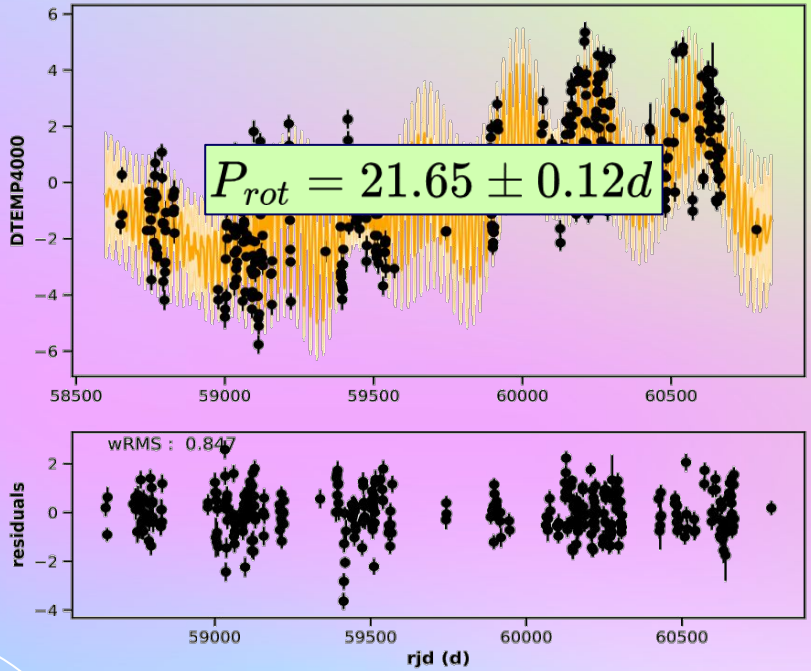




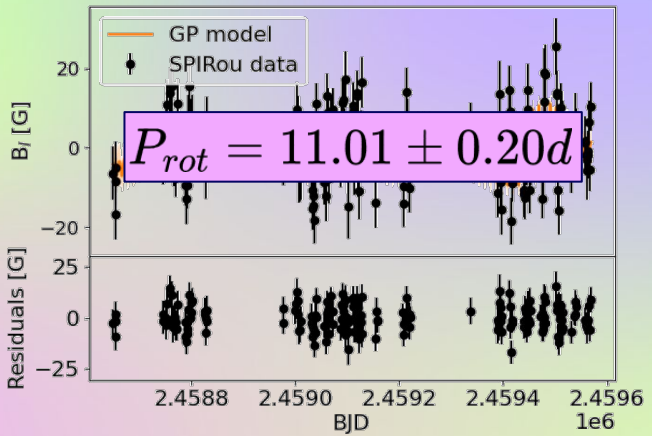
Sample of 43 stars in both B*ı*studies of **Fouqué et al. (2023)** and **Donati et al. (2023b)**, all included in our sample. Our study with *dTemp* constrain the period for 37 of them

GI 846 Period harmonics

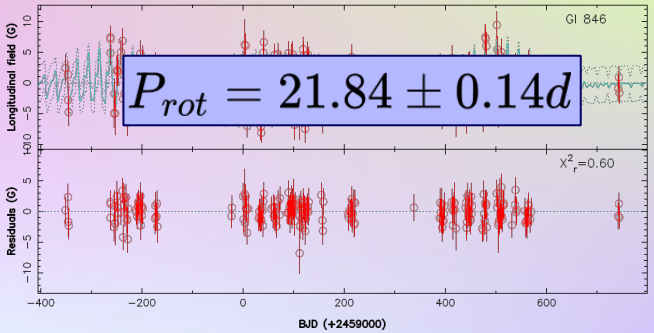
Our analysis



Fouqué et al. (2023)



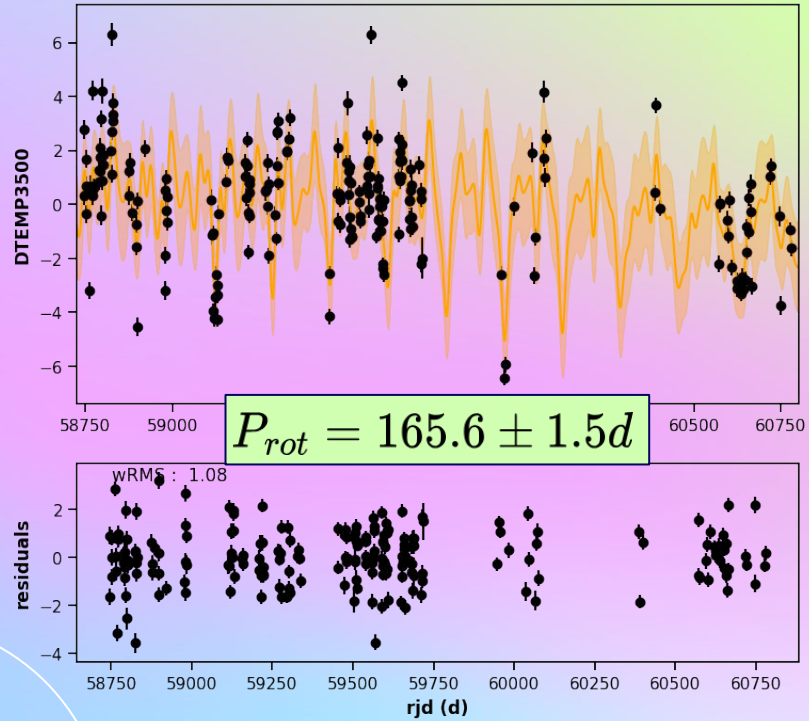
Donati et al. (2023b)



Similar results for **GI 480**

GJ1105

Our analysis



Bℓ analysis (Fouqué+2023 & Donati+2023b)

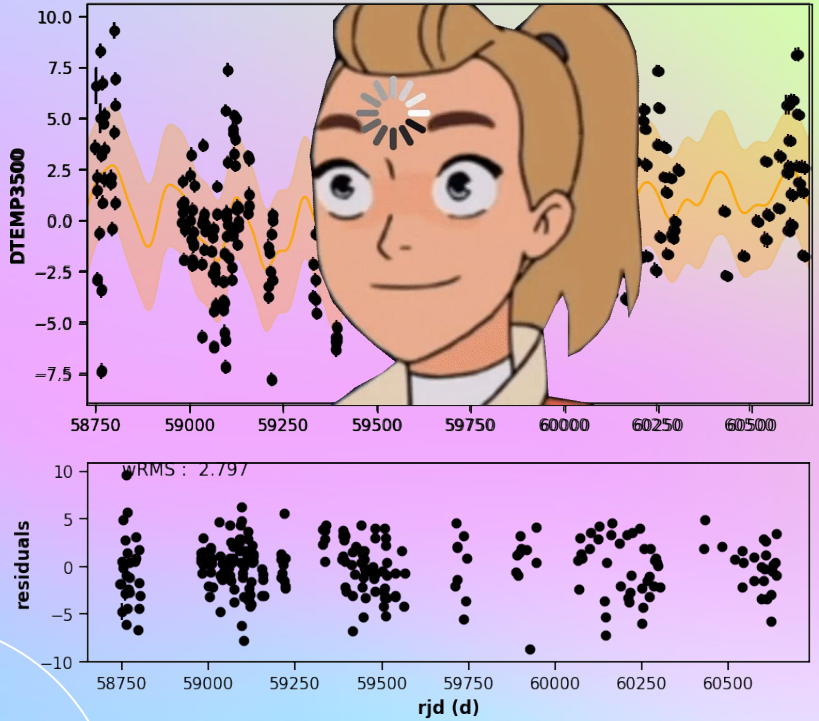
404

NOT FOUND

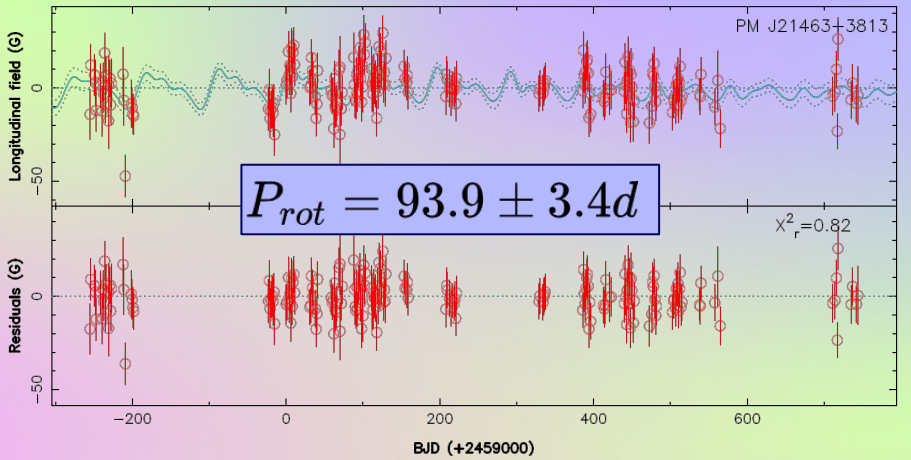
Similar situation for **Gl 445, GJ1012, GJ1148**

PM J21463+3813

Our analysis

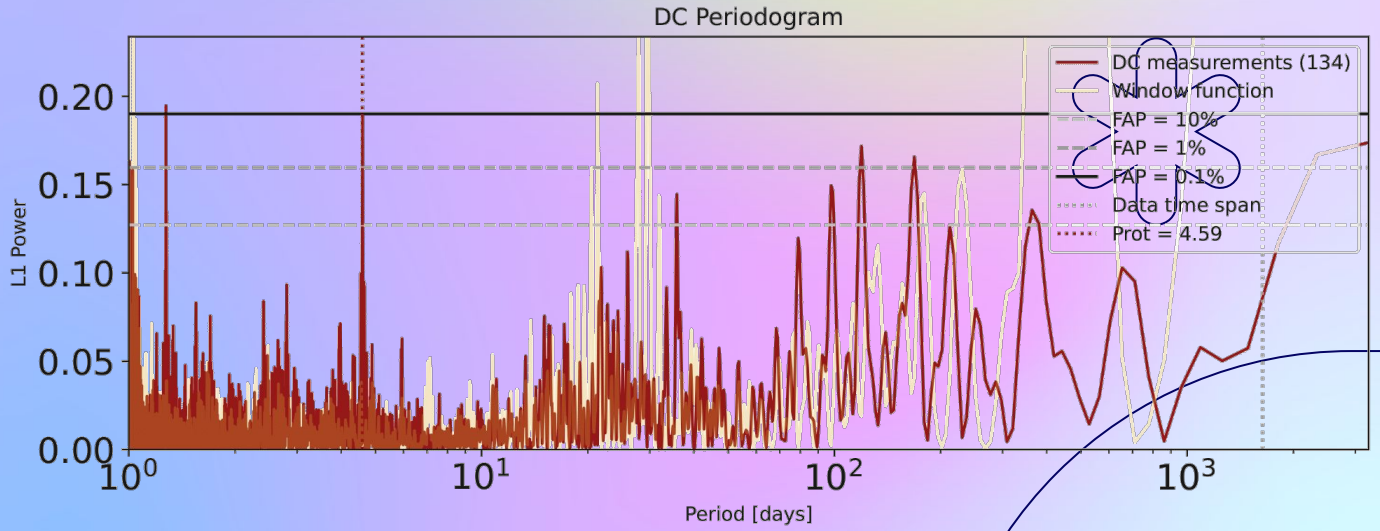


Bℓ analysis (Donati+2023b)



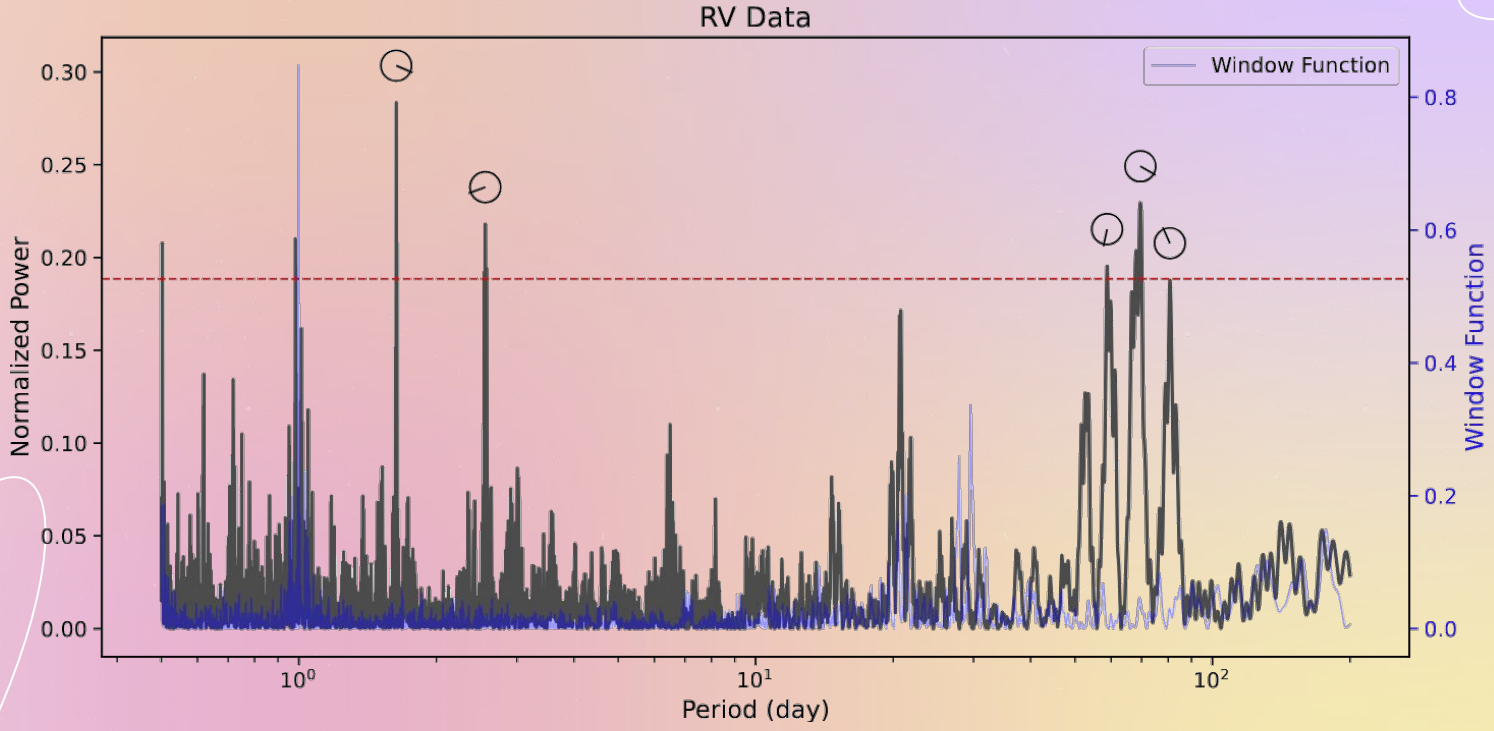
Similar situation for **Gl 447**

The **contrast effect**



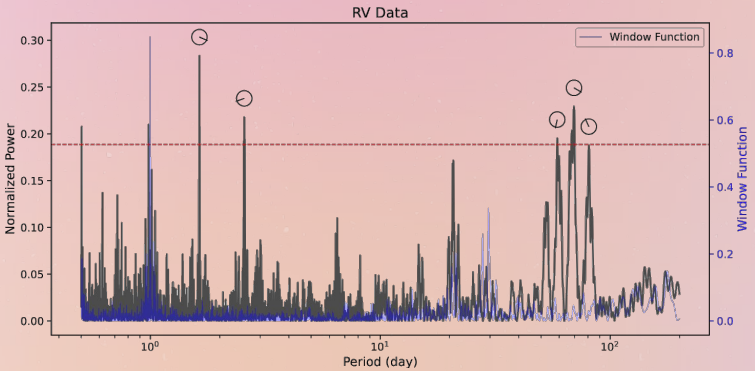
By separating lines with C>1 and C<1, then subtracting their RV series, the two **activity contributions add constructively** while planetary signals cancel out.

Are they the *real periods* ?

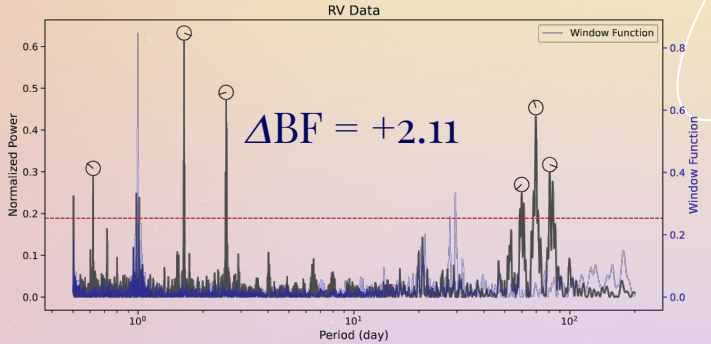


Alias analysis.

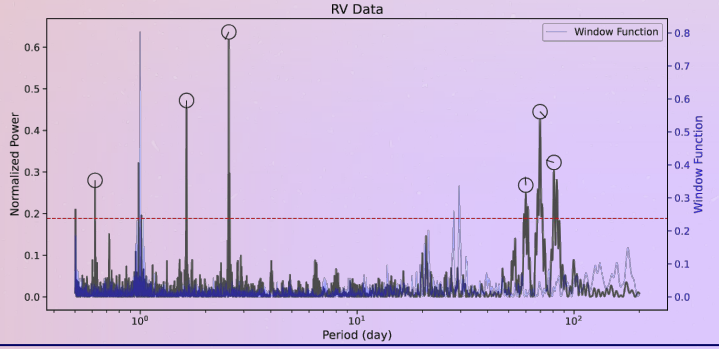
Real data



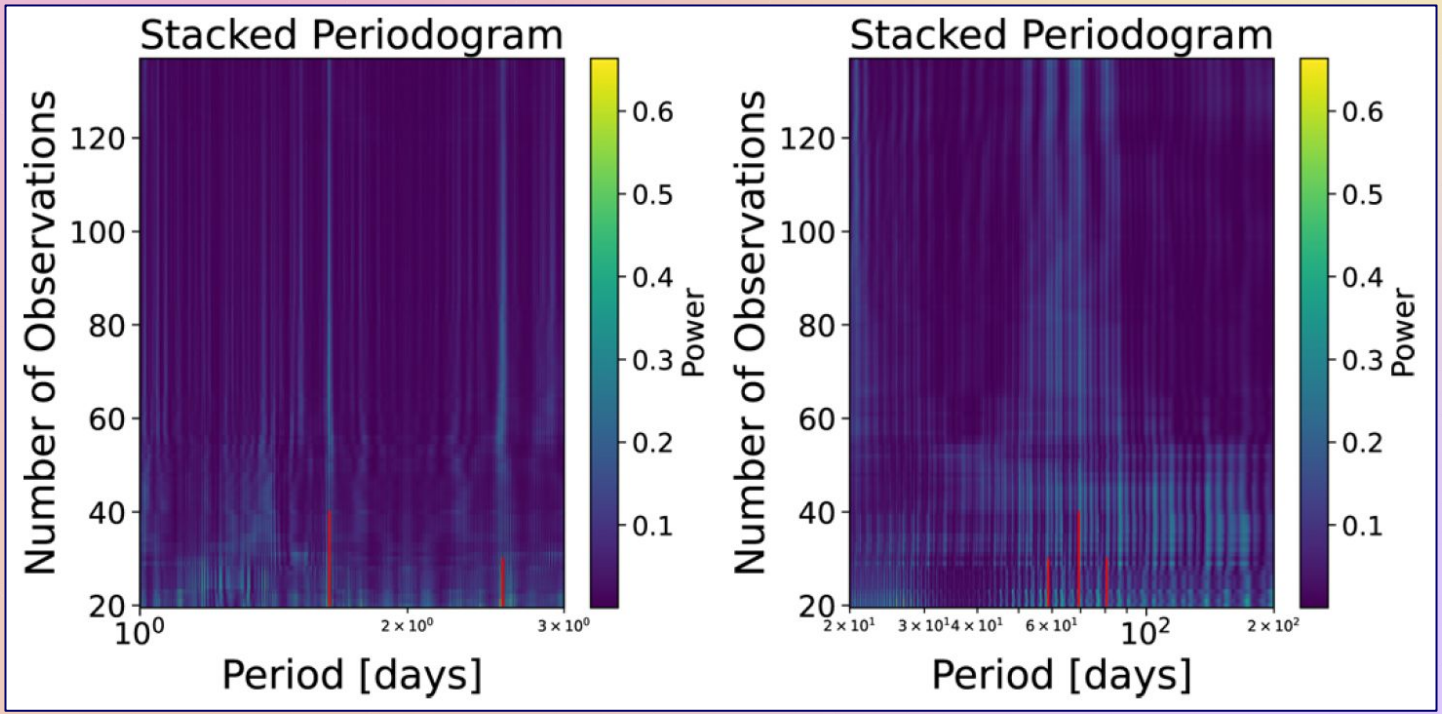
(b) Model of two circular planets with orbital periods of 1.63 d and 69 d.



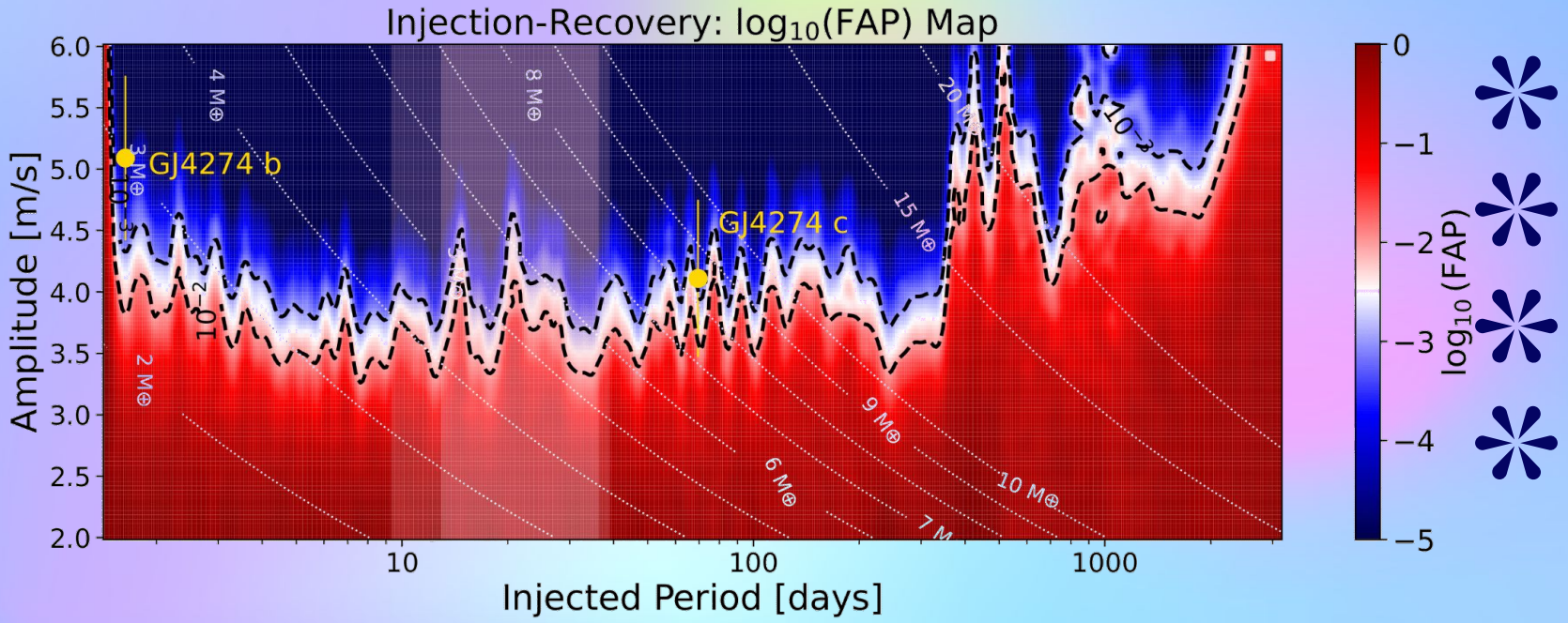
(c) Model of two circular planets with orbital periods of 2.56 d and 69 d.



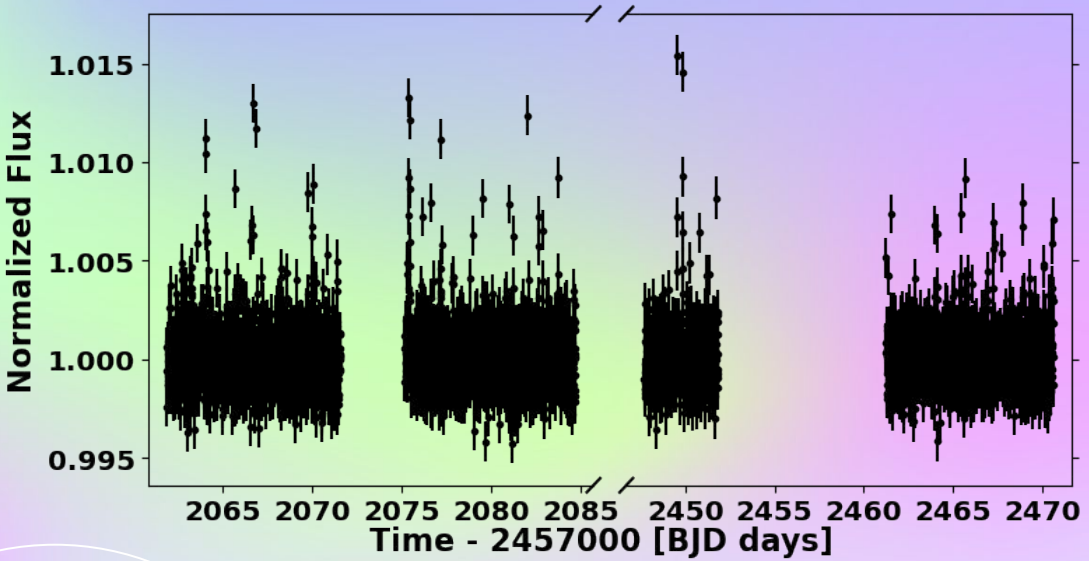
Stacked periodograms



Could there be **more planets?**



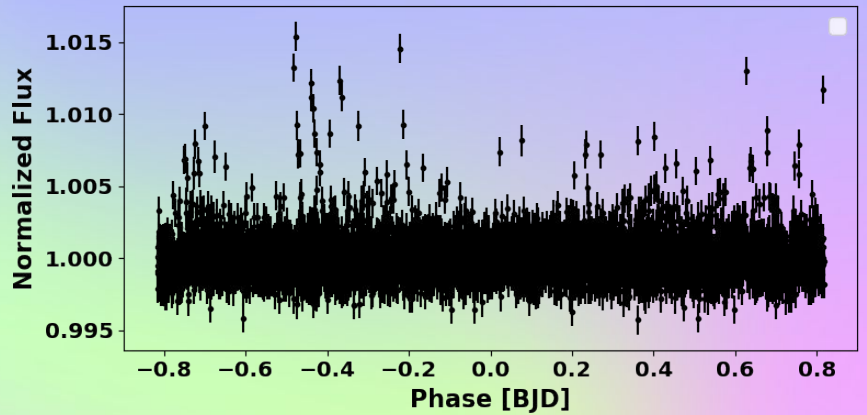
Analysis & development

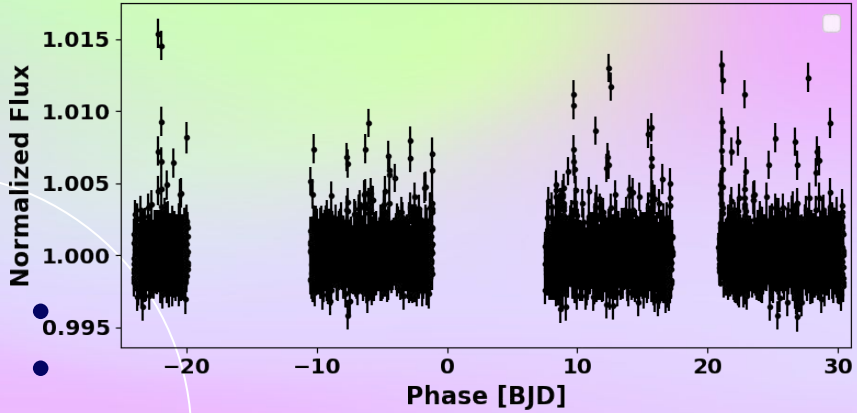


TESS transit data

GJ 4274 has been observed during campaign 28 & 42 (Aug2020 & Aug2021).

Analysis & development



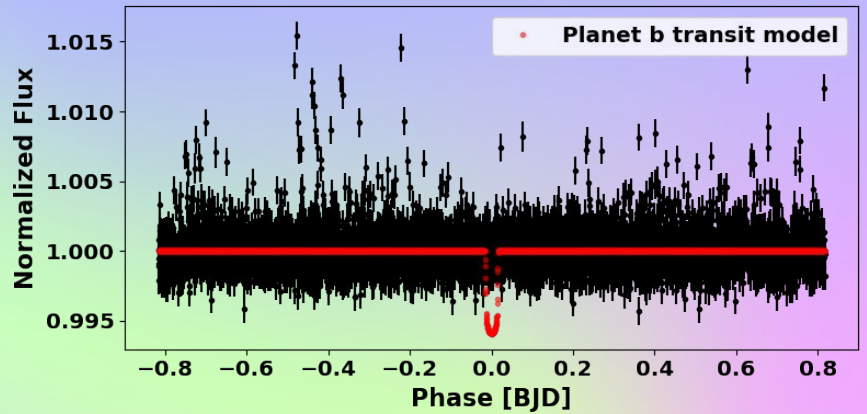


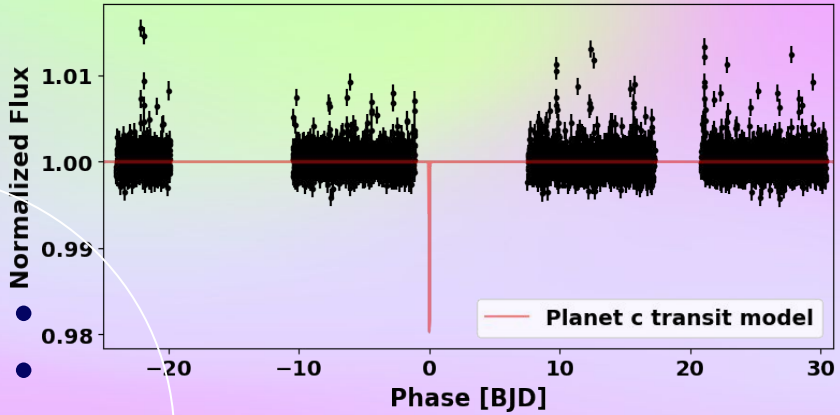
TESS transit data

GJ 4274 has been observed during campaign 28 & 42 (Aug2020 & Aug2021).

No transits detected

Analysis & development





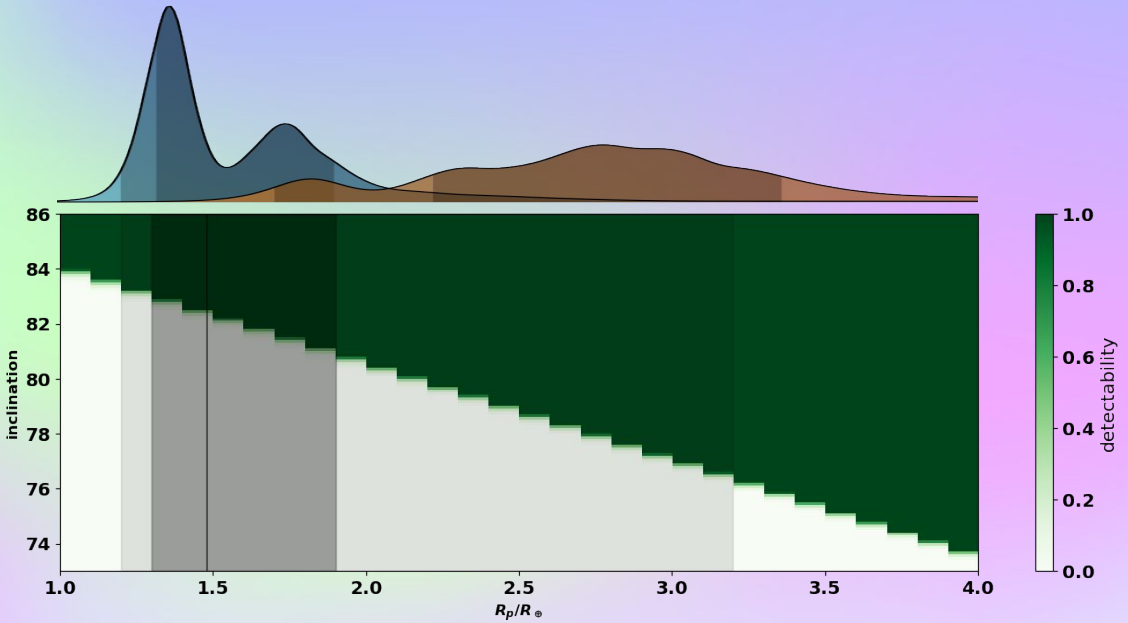
TESS transit data

GJ 4274 has been observed during campaign 28 & 42 (Aug 2020 & Aug 2021).

No transits detected

$$i_b < 83^\circ$$

Transit.



$i_b < 83^\circ$

TESS data

GJ 4274 has been observed during campaign 28 & 42 (Aug2020 & Aug2021).

No transits

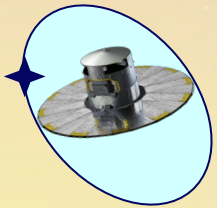
Using nominal values, we should see the transit if star-planet alignment

Constrain the inclination

From injection recovery test

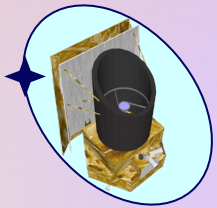
Astrometry .

Planet c : $\frac{\alpha}{sini} = 3.63 \pm 0.86 \mu as$



Gaïa

Just ended
(DR until 2030)
Precision 20-25µas



Theia

ESA/M5 mission
Awaited for 2030s
Precision < µas