A multi-wavelength view of M dwarfs activity with SOPHIE and SPIRou: characterizing low-mass planets

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Main takeaways

- 🔥 Studying the **chromaticity of the stellar activity** signal helps us to disentangle activity from planetary signals
- 🔭 **SOPHIE and SPIRou** work together to characterize the stellar activity of M dwarfs in the optical and nIR domains.
- 💥 Rule-out of the planet candidate orbiting the active M dwarf **AD Leo**
- 💻 Modelling of seasonal stellar activity signals with **multi-dimensional GPs** of the early M dwarf Gl 205
- 🪐 Detection of a **potential super-Earth** orbiting the primary component of a close M dwarfs binary system

Introduction

M dwarfs are expected to host low-mass planets [1], however the stellar activity jitter in the RVs is one of the main limitation to find them, as its contribution can be of the order of m/s.

The synergy program between **SOPHIE at OHP** and **SPIRou at CFHT** enables to characterize **stellar activity** in the optical and nIR with quasi-simultaneous observations.

Here we present the main results of the project focused on the analysis of AD Leo, Gl 205, and a close M dwarf binary system.

AD Leo b is stellar activity!

Long-term controversy regarding the detection of planet b in a 2.23 days period, co-rotating with the star [2].

Previously, HARPS and GIANO did not find the planet's signal [3]

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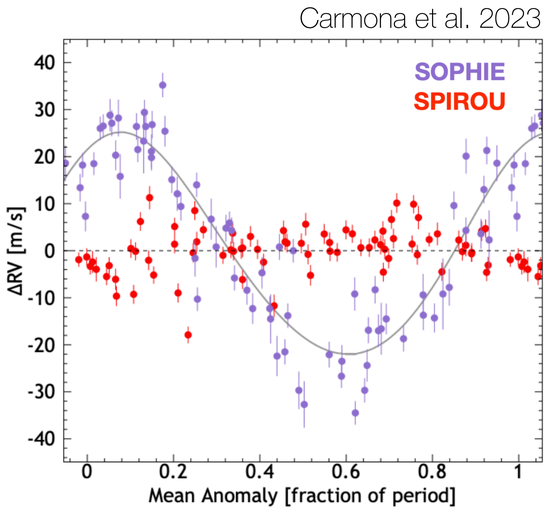


Using SOPHIE+SPIRou data [4], we ruled out the presence of a planet orbiting AD Leo and confirmed the stellar origin of the observed RVs. While the optical RVs show a signal with an amplitude of ~20 m/s and periodicity of 2.23 days, the SPIRou RVs are mostly flat with no periodic signal.

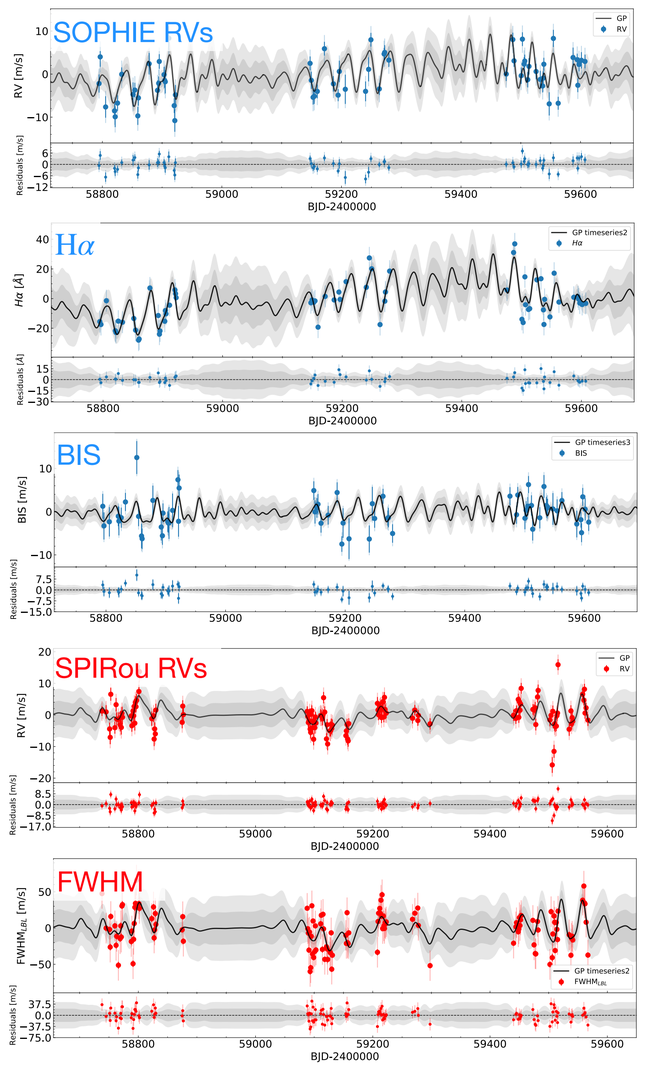
Gl 205: multi-dimensional GPs in the optical and nIR

We used *pyaneti* [5] to perform a **multi-dimensional GP regression** to filter the stellar activity signal in the SOPHIE and SPIRou RVs [6].

Ancillary time series:
- $\mathrm{H}\alpha$ and the BIS for SOPHIE
- $\mathrm{FWHM}_{\mathrm{LBL}}$ for SPIRou.

The **remaining RV jitter:**
- SOPHIE:
$$2.75^{+0.57}_{-0.54}\ \mathrm{m/s}$$
- SPIRou:
$$2.70 \pm 0.30\ \mathrm{m/s}$$

No planetary signals remained in the residuals.



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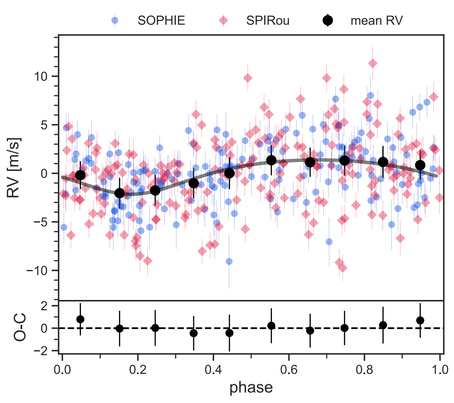
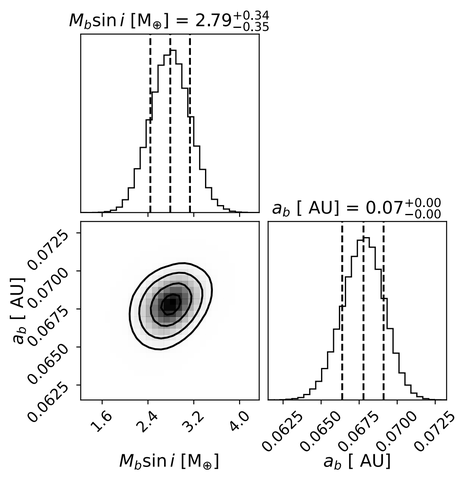
A potential super-Earth in a close M dwarf binary system

We discovered one of the closest super-Earth candidates orbiting the primary component of a M dwarf binary system. No transit event was found in the analysis of 26 TESS sectors. Mass-radius relationships suggest $R_p < 2R_\oplus$

$$P = 11.2202 \pm 0.0049\ \mathrm{d}$$
$$K = 1.7 \pm 0.2\ \mathrm{m/s}$$
$$M \sin i = 2.79 \pm 0.35\ \mathrm{M}_\oplus$$





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References

[1] Bonfils et al. 2013
[2] Tuomi et al. 2018
[3] Carleo et al. 2020
[4] Carmona et al. 2023
[5] Barragán et al. 2022
[6] Cortés-Zuleta et al. 2023

Further questions?

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