Extracting Radial Velocities using WOBBLE from SPIRou Data

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Introduction

Radial velocities (RVs) in near inferred (NIR) band are crucial for planetary research, especially for the detection and characterization of planets around M dwarfs. However, obtaining precise near-infrared RVs can be challenging due to the Earth's atmosphere (telluric). Bedell et al. (2019) have presented a data-driven package, **wobble,** to extract RVs and have shown good performance in the optical band. Since **wobble** can extract RVs without prior knowledge of the star or the Earth's atmosphere, we adopted wobble for CFHT-SPIRou data and tested its performance.

Pipeline

Adopting the SPIRou spectra with tellurics subtracted using the PCA method (Artigau et al. 2014b)

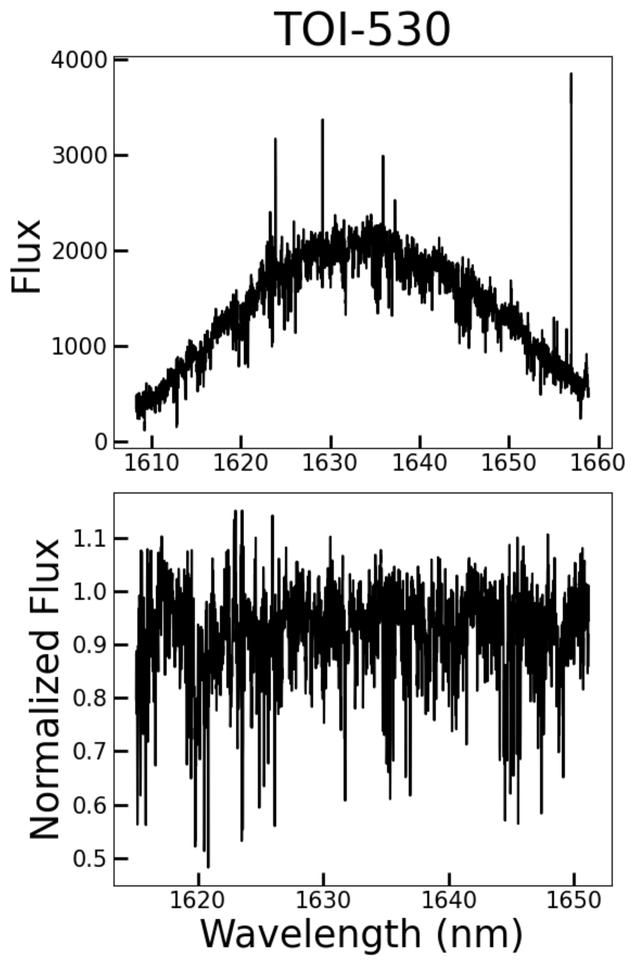
→ Emission lines rejection

→ Normalization with state-of-the-art algorithm, AFS (Xu et al. 2019)

→ Extracting RVs of each order with **wobble**

→ Combining RVs with a different method than wobble (we use a simpler outlier rejection + weighting scheme)

Example spectrum before and after emission lines rejection and normalization:



Science Result: TOI-530b

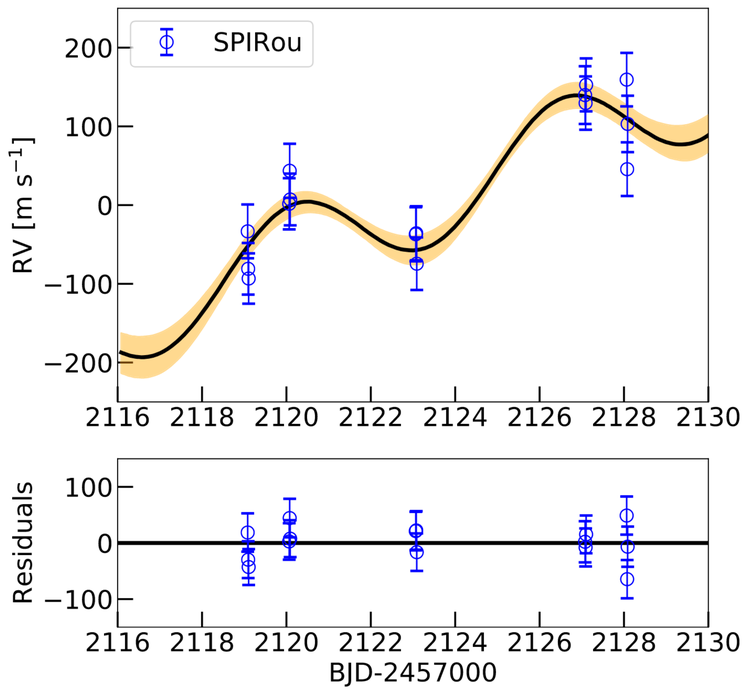
(Gan et al. 2022a, MNRAS)

The sixth transiting giant planet hosted by an M-type star, which is predicted to be infrequent according to core accretion theory

· Planet Mass: 0.37 ± 0.08 M_J
· Planet Radius: 0.83 ± 0.05 R_J
· Period: 6.39 day

· Host Star's Mass: 0.53 ± 0.02 $M_\odot$
· Effective temperature: 3659 ±120 K

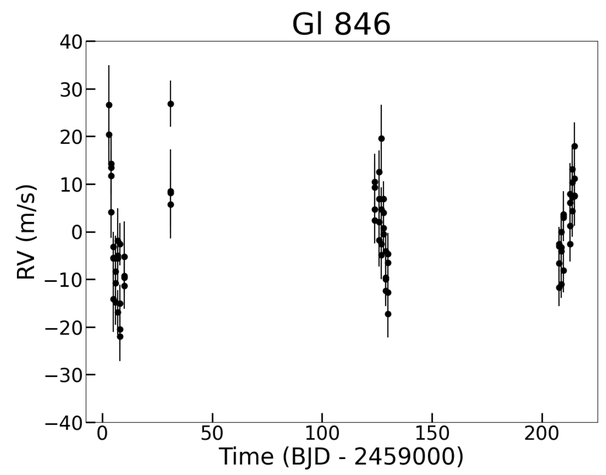
RV results:



These RV results exhibit a linear trend, which may be due to pipeline systematics, though not supported by our other tests (right plots). We are investigating whether this is caused by residuals from telluric subtraction at the moment.

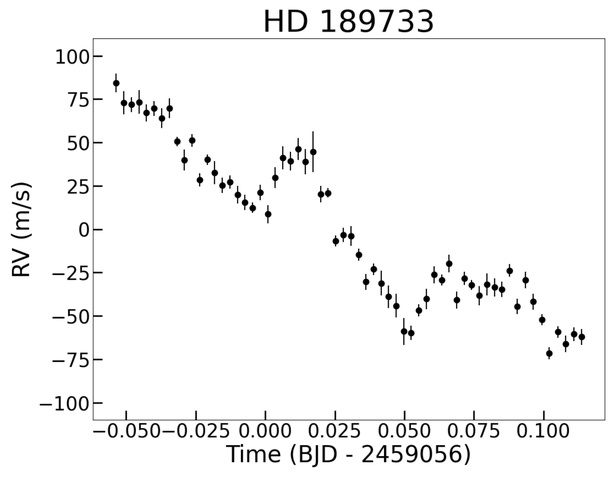
Test Results:

Standard star: Gl 846



Standard deviation ~ 10 m/s

RM target: HD 189733



Comparison with other pipelines

Artigau et al. (2022) also published a new algorithm, line-by-line (LBL), to extract RVs from SPIRou spectra. LBL has better precision than our rustic wobble pipeline (e.g., on TOI-2136; Gan et al. 2022b). Further fine-tuning of wobble is necessary to enhance its precision.