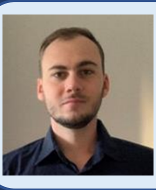

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Automated Search for Exocomet Transits

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Abstract

- Exocomet detection = variable absorption features in stellar spectra around the ionized Calcium doublet
- Search algorithm looks for those transient absorption features for all 6401 stars observed by HARPS
- Algorithm shows fewer interesting detections than literature prediction (results mainly contaminated by stellar activity)
- Current work in refining the search method to allow for more accurate/precise results (target filtering with SOM, spectral processing to improve sensitivity, etc…)

1. BACKGROUND

- Exocomets = Extrasolar comets
- Formed from the small building blocks that create planets
- Detect coma via spectroscopy – nucleus too small to observe
- Algorithm tailored around the exocomet detections found for the star *Beta Pictoris – archetypal star in exocomet field*

Aim: **Observe the interaction between the exocometary gas and the light emitted by a star - Fig1b.**

How: **Searching for transient absorption features in the ionized Calcium doublet (CaII H & K) - Fig1a.**

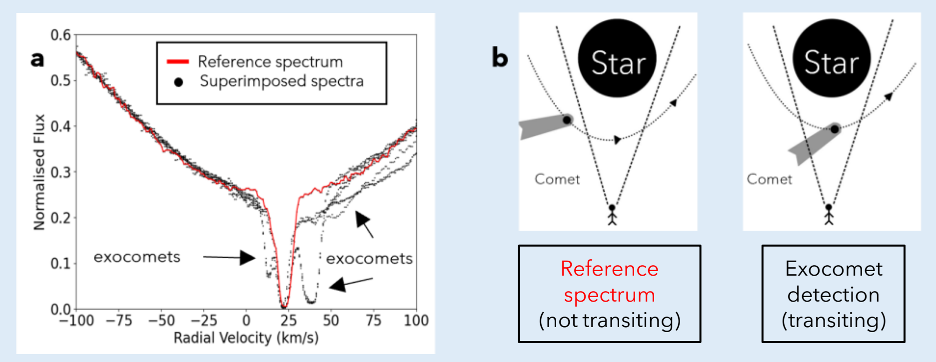

Fig1a. Transient absorption features in *Beta Pictoris* (CaII K Line 393.366 nm). These exocomet features vary from night to night.
Fig1b. Schematic of how an exocomet is detected.

2. METHODS OF EXOCOMET SEARCH

Reference spectrum: All spectra for a single star are combined to form a median reference spectrum.
Search algorithm: Quantify the difference between each spectrum and reference spectrum (accounting for a definition of noise) - **Eq1.**

$$\mathrm{SNR} = \frac{\mathbf{spectrum} - \mathbf{reference}}{\mathbf{noise}} \qquad \mathrm{noise} = \sqrt{\sigma^2_{\mathrm{spectrum}} + \sigma^2_{\mathrm{reference}}}$$

Eq1. Exocomet detection algorithm –ie. Signal to Noise Ratio (SNR).

3. RESULTS OF EXOCOMET SEARCH

***Aim*: Search through the dataset for exocomet transits**

Dataset: The entire High Accuracy Radial velocity Planet Searcher (HARPS) archive – 254025 spectra/ 6401 stars

***Results*: ~6% candidates detected in search**
39% early type stars (O, B, A) and 61% late type stars (F, G, K, M)

Late type star detections are mainly false positives: caused by stellar activity - Fig3b.

4 candidates (A, B stars) are considered interesting – 0.06%

From literature *(Rebollido et al. 2020, Iglesias et al. 2018)*, **0.14%** of sample of random stars should show exocomet-like absorption features.

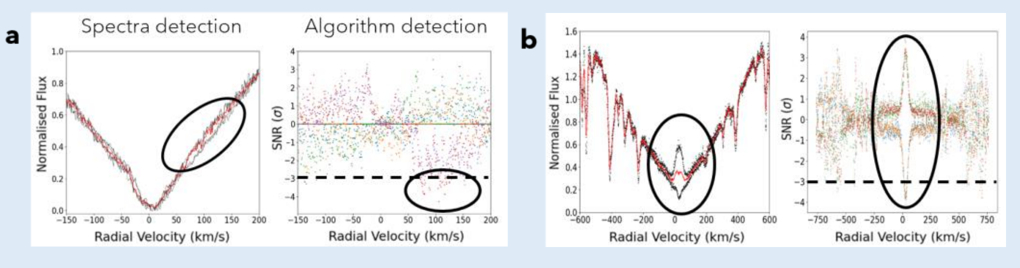

Fig3a. Detection around a star known for its planet formation.
CaII K – Herbig Ae/Be *HD145718*

Fig3b. False positive caused by changes in stellar activity.
CaII K – G2 type star (*HD179211*)

Next steps:
- What stars show stellar activity and how much do they vary? **- Section4.**
- How to filter out/pick out these false positives? **- Section5.**

4. QUANTIFYING STELLAR ACTIVITY

***Aim*: Observe variations in CaII K absorption vs. B-V - Fig4b.**

***Goal*: Illustrate that late type stars show higher level of activity than early type stars - Section3.**

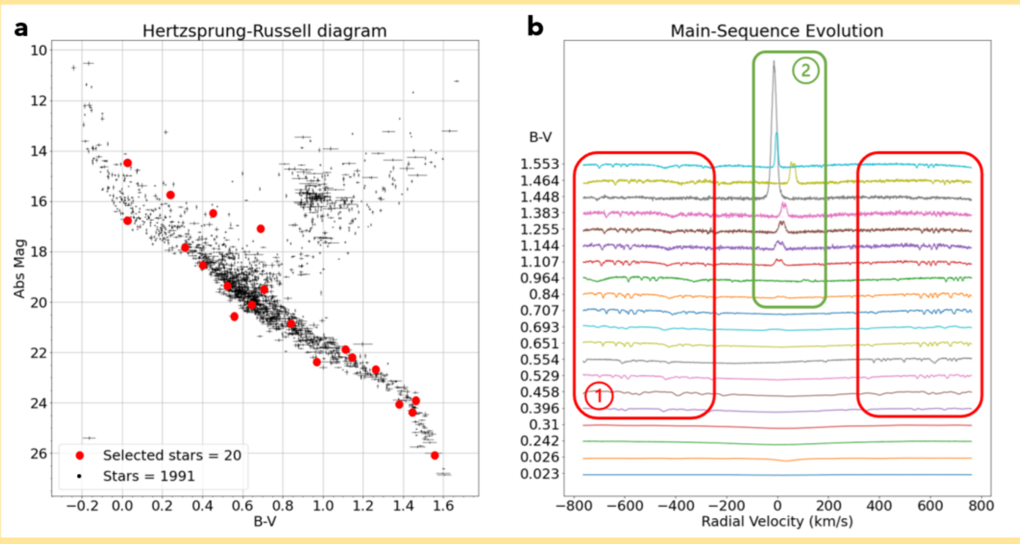

Fig4a. Hertzsprung–Russell diagram of full dataset
Fig4b. Evolution of the CaII K line along the Main Sequence showing stellar activity near 0 km/s (only in late type stars) that can cause false postive exocomet detection.

5. SELF-ORGANISING MAP (SOM)

Def: Machine Learning tool that learns the features of input data, to then group them according to the similarity between one another.

Aims:
- **Classification of stars according to spectral features – Fig5a.**
- **Query the best matching group for a specific star – Fig5b.**

Goals:
- **Preliminary filtering of false positive detections – Section3.**
- **Query similar looking stars to identify possible interesting candidates**

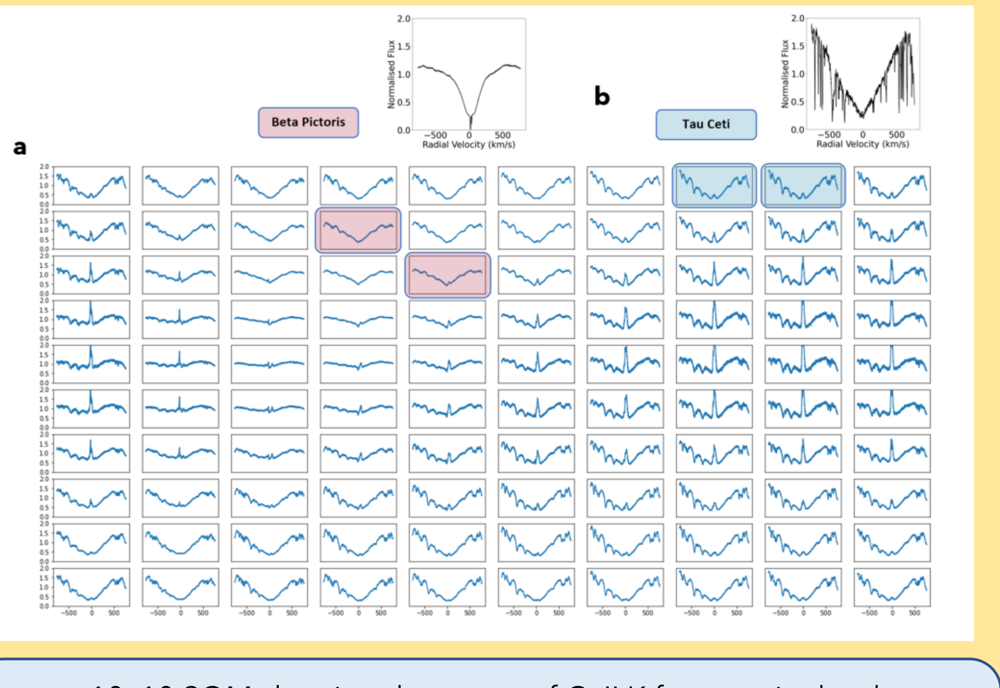

Fig5a. 10x10 SOM showing the range of CaII K features in the dataset
Fig5b. Matching specific stars to groups in the SOM
red: best matching groups for the 5480 spectra of *Beta Pictoris*
blue: best matching groups for the 556 spectra of *Tau Ceti – Sun analogue*

FUTURE WORK

Aim: **Refining search algorithm/results to publish a paper**

Refining search algorithm includes:
- Radial velocity correction to the spectra for more accurate matches with SOM
- Increase sensitivity of detection method
- Applying algorithm to other absorption lines

Questions?

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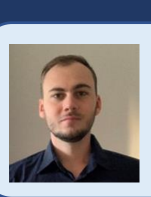

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