Removing Stellar Activity from RVs Using Machine Learning

Zoe de Beurs, University of Texas at Austin

Andrew Vanderburg, University of Madison-Wisconsin

Chris Shallue, Center for Astrophysics, Harvard-Smithsonian

HARPS-N Solar Telescope Collaboration

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RV Method: Planets introduce \textit{translational} shifts to CCF

- Sun moving \textit{towards} us
- Sun moving \textit{away} from us
Problem: Stellar activity changes the **line shape** of CCFs
Our solution: Train a neural network to remove stellar activity noise
What information do we give the neural network?
What **information** do we give the neural network?
Training Set: 
HARPS-N Solar Telescope Observations

HARPS-N Solar Telescope

- A high-precision spectrograph
- Located on the Telescope Nazionale Galileo (TNZ) in La Palma, Canary Islands, Spain
- HARPS-N Observations from July 2015 to December 2018
For Solar Data, we reduced RV jitter by a factor of \( \sim 2 \) using these methods.
Our results in the form of periodograms
Reduce the number of CCF inputs, still a significant reduction in RMS.
Could this work for nighttime data?
Test case: bright star with a validated planet (observed with K2, TESS, HARPS-N)
What do these CCFs look like for this extrasolar star? Can we simultaneously fit Keplerians & CCF parameters?
PRELIMINARY

Activity Correction

Detected at 2.3σ in Raw RVs
Detected at 4.0σ in Stellar Activity Corrected RVs

Raw RVs vs Stellar Activity Corrected RVs

Fitted Planet
Unbinned points
Binned points
Conclusion and Future Directions

- Machine learning methods can reduce stellar activity jitter by a factor of ~2 for our Sun, paving the way towards higher precision RVs.

- In the future, we want to continue this synergy between solar and extrasolar observations to further the goal of mitigating stellar activity and ultimately detecting smaller planets around bright nearby stars.
Questions?