

Search for Laser Emission Lines with the APF

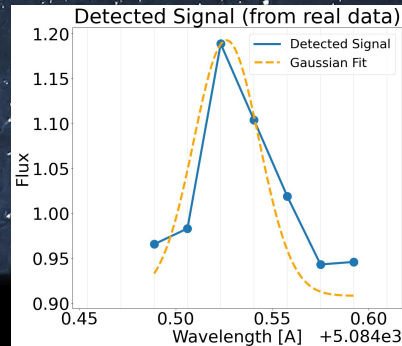
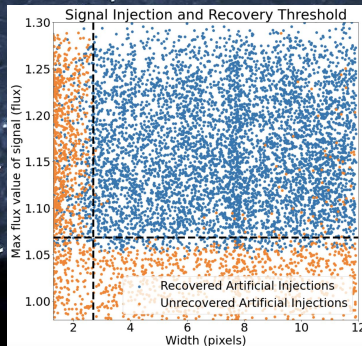
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Optical lasers are promising interstellar communication tools, as they offer both high intensity and privacy. My project is a search for laser emission lines that could be communication from extraterrestrial intelligence.

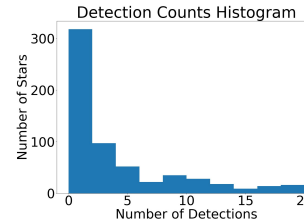
Methods

I search through stellar spectra from the Automated Planet Finder by going through the following steps: I first identify all the pixels above a certain threshold, which I define as $T = n * m$, where m is the median flux value of all the lines above the continuum level, and n is set to 1.05 to maximize detection and minimize false positives. I then fit a Gaussian to each signal that exceeds the threshold and run a chi-squared test that measures how closely the signal fits the Gaussian. If chi-squared is under 11, the signal is categorized as Gaussian-like and moves on to the final test. If the FWHM of the fitted signal is greater than 2.7 pixels, which is the width of the point spread function of the APF, the signal moves onto the next step in verifying it as an extraterrestrial laser emission line. I tested my algorithm by running a signal injection and recovery technique. I injected 2,000 spectra with 6 artificial signals each and ran my algorithm on the spectra, obtaining a 74% detection rate for signals wider than the PSF and a 99% detection rate for signals wider than the PSF and with flux values exceeding the established threshold. I ran the algorithm on 5,866 spectra from the APF, which corresponds to 852 unique stars. For each star, I calculated the median number of detections across all its spectra.

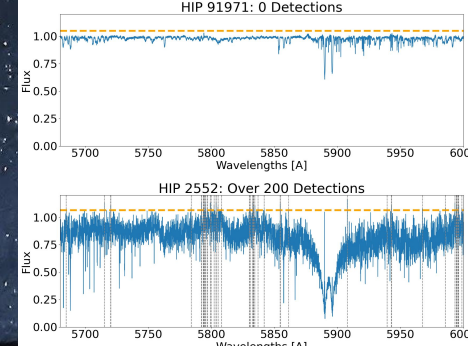


Results

45,756 detections in 5,866 spectra corresponding to 852 stars



448 spectra have over 200 detections, and 1,050 spectra have 0 detections.



Conclusion

For stars with low S/N, there is a large number of detections due to noise. Conversely, for some stars with high S/N, there are no detections. Further improvements on the detection algorithm include modifying the threshold based on S/N. Instead of setting n as 1.05, n can depend on the S/N ratio, raising the threshold for noisy data and lowering the threshold for cleaner data. The APF spectra offer an abundance of data that may contain laser emission lines from extraterrestrial intelligence. With 245,756 total detections among 852 stars, I will begin omitting false positives such as cosmic rays to identify the signals that do not have a known astrophysical or terrestrial source.

References

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- Tellis, Nathaniel K., and Geoffrey W. Marcy. "A search for optical laser emission using Keck HIRES." *Publications of the Astronomical Society of the Pacific* 127.952 (2015): 540.

Acknowledgements

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