Measuring Extreme Precision Radial Velocities (EPRVs) in the Presence of Stellar Noise using Deep Learning

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Stellar variability is one of the largest contributors to noise in Extreme Precision Radial Velocity (EPRV) measurements. We are developing deep learning-based approaches to measure small injected planet-like RVs in the presence of larger amplitude RV signals caused by stellar and instrumental noise. We have developed multiple neural network-based approaches trained using the HARPS-N sun-as-a-star extracted (order-by-order) spectra from 2015-2018. A variety of planet-like RVs are injected into the spectra prior to training the neural networks and the planet-like RVs from a separate test subset are recovered after training. Our current approach is able to measure injected planetary RVs to ~1 m/s RMSE on HARPS-N sun-as-a-star spectra. The unprecedented signal-to-noise and cadence of sun-as-a-star spectra allow us to evaluate the effectiveness and limitations of neural networks at separating stellar and planet-induced RVs in the wavelength domain at sub-m/s precision, and determine their applicability to the EPRV community's goal of mitigating stellar RV variability. Finally, our end-to-end injection and recovery approach sets a new standard for EPRV noise mitigation methods.