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IGRINS RV: A Python Package for Precision Radial Velocities with Near-Infrared Spectra

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- Review
- Repository
- Archive

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Summary

The relative velocity of a star with respect to the Sun can be calculated from its electromagnetic spectrum using the Doppler Effect. This line-of-sight motion, called the Radial Velocity (RV), is an essential tool for astrophysicists. RVs are not only used to detect and characterize exoplanets, but also play a key role in studies of binary stars, star clusters, and moving group member identification.

In the past decade, RVs have primarily been measured from spectra in the optical wavelength regime. This is partly because of advancements in detector technology, but also because of the paucity of Earth's atmospheric absorption features (telluric lines) in the optical. Yet for a fainter, cooler, smaller stellar object like an M type star (stars with mass less than half of the Sun), which emits more energy in the Near-Infrared (NIR), observations in the NIR can save a considerable amount of exposure time. Also, the M type star is the most common type of star. This along with its size increases the detectability of Earth-like planets around them. Moreover, the stellar activity that can drive false positive exoplanet detections, e.g., star spots carried into view by stellar rotation or gas accretion from the circumstellar disk in young star system, is shown to be less severe in the NIR compared to optical.

`IGRINS RV` is a pipeline built for extracting precision RVs from spectra taken with the Immersion GRating INfrared Spectrometer (IGRINS) spectrograph (G. Mace et al., 2016; Gregory Mace et al., 2018; Park et al., 2014; Yuk et al., 2010). This pipeline is built on the forward-modeling methodology that was successfully applied to CSHELL and PHOENIX spectra in the past (Crockett et al., 2012). However, `IGRINS RV` gives three times better RV precision to about 25–50 m/s shown by yearlong monitoring on two RV standard stars, GJ 281 and HD 26257. This improvement is because of the use of a more robust approach to wavelength calibration and a better telluric modeling. `IGRINS RV` has also demostrated its effectiveness in identifying hot Jupiters by successfully recovering the planet induced RV signal from HD 189733 and Tau Boo A. `IGRINS RV` lets users choose to obtain absolute RVs or relative RVs, depending on whether their priority is precise RV monitoring or more coarse RV characterization. `IGRINS RV` requires that the `igrins plp v2.2.0` (Lee et al., 2017) and `Telfit` (Gullikson et al., 2014) packages be pre-installed. Detailed documentation and tutorials can be found on the GitHub wiki page.

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