Using exoplanet systems with highly elliptical orbits to search for star-planet interactions

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Abstract: We have undertaken a study to determine if the orbital geometry of exoplanets affects the activity of their host stars by studying a sample of planetary systems known to contain massive planets on short period, highly elliptical orbits. While recent studies in the optical, UV, and X-ray have shown enhanced chromospheric activity for stars hosting exoplanets with orbital semi-major axes less than 0.1 AU (Krejčová 2012, Shkolnik 2013, Kashyap 2008, Poppenhaeger 2010), it is not yet clear whether this activity is driven by magnetic or tidal interactions. For the first portion of our study, we are probing the dependence of star-planet interactions (SPI) on the orbital geometry of the planetary systems by analyzing the Ca II H & K emission lines for variability phased with the exoplanet’s orbit. We have obtained high resolution spectra of several systems with the McDonald 2.1m Sandiford echelle spectrograph and ARCES on the APO 3.5m. For the second part, we are analyzing the high precision short cadence Kepler light curves of a few Kepler host stars to look for modulation signature of a hot spot generated on the stellar disk as a result of SPI. We shall describe our methodology and then review our results on how orbital geometry can be used to study how planets may affect the activity of their host stars.

Background: The discovery of hot Jupiters led to the search for evidence of various interaction scenarios between these massive planets and their host stars. Recent statistical analyses of data in multiple bands has shown increased chromospheric activity in stars harboring planets closer than 0.1 AU. Ongoing observational work has produced evidence that the magnetic fields of some of these stars may interact with magnetic fields of their planets. The results of these interactions can be explored in the stellar chromosphere by looking for variations in the Ca II K line core phased with the planet’s orbit.

Procedures:
We are investigating the planet induced chromospheric activity of each star by examining the Ca II HK (3933, 3934), Ca II IR (8562), and Hα (6563) lines in our phase observed spectra. We are monitoring the AI I line (3944), an indicator of photospheric activity, to ensure any modulations in the chromospheric lines are not a result of intrinsic stellar processes. (For Ca II HK and AI I lines, see below.)

Table 1. Properties of planetary systems being analyzed for SPI. HD 179939 and HD 131879 have been confirmed to show evidence of SPI by Shkolnik (2013). The eccentric SPI candidates listed are some of our target stars. Planets in elliptical orbits experience a very wide range of stellar environments along their orbit. Along a planet’s orbital motion, the effective radius of a planet will experience variations.

Summary:
We have undertaken a spectroscopic search for SPI in planetary systems harboring hot Jupiters in highly eccentric orbits to investigate how orbital geometry may affect SPI. A photometric search for SPI is also being conducted using the short cadence Kepler data. Our initial results are encouraging and call for the continued search for star-planet interactions.

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References

The time series and their resultant periodograms will be analyzed for modulations phased with the planetary orbit, stellar rotation, and the synodic period of the stellar rotation.