Identifying Extra Solar Planets and their Key Features using the Doppler Wobble and Planetary Transits Methods

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Abstract

This is the abstract

Introduction and Background

The Doppler Wobble Method of extra-solar planets

For the analysis on data of two stars and the existence of an extra-solar planets around them, the doppler wobble method was used. This method is based on measuring the radial velocity of the stars (HD-28185 and HD-73256) as they move towards and away from the observer. Thus producing a doppler shift in the light emitted from the stars, that can be used to determine the velocity of the stars in the plane of the observer's line of sight.

To determine the radial velocity, observations were made of the stars on different Julian dates, recording the wavelength of light emitted as well as the observed intensity of the light. The radial velocity of the stars can then be calculated using the doppler shifted wavelength and intensity, as provided in the Python Library.[1]

$$\lambda_{obs} = \lambda_{emit}(1 + v/c) \tag{1}$$

$$I_{obs} = \frac{I_{emit}}{(1 + v/c)} \tag{2}$$

where λ_{obs} is the observed wavelength, λ_{emit} is the emitted wavelength, I_{obs} is the observed intensity, I_{emit} is the emitted intensity, v is the radial velocity of the stars and c is the speed of light. From this it was possible to calculate the radial velocity of each star on each date. This was done using the Python SCIPY library.[2] An uncertainty in the radial velocity was assigned to each date of each star of $\pm 15ms^{-}1$.[1]

When plotting the radial velocity as a function of time, as seen in figure 1, it was possible to see that there was a periodic sinusoidal pattern in the data, however, it was not very accurate as the time between observations varyed. To correctly plot the radial velocity of the stars over time it was neccessary to calculate the phase of each star through the period of the orbit. In this

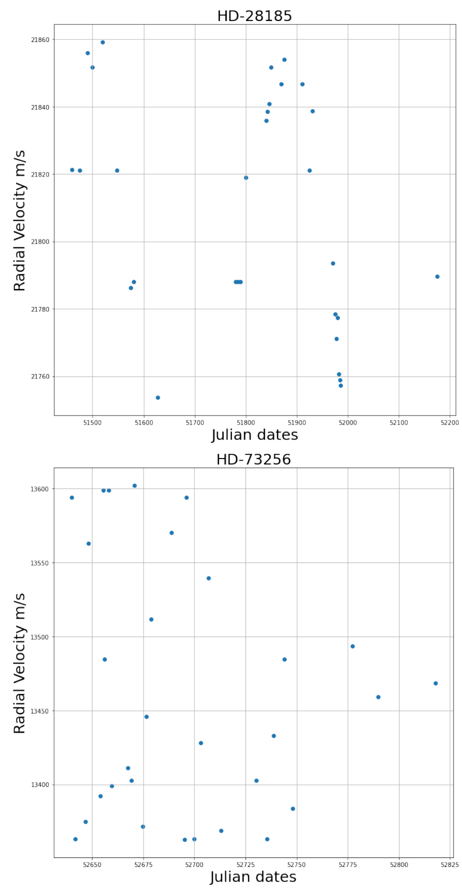

Figure 1: Radial velocity of HD-28185 and HD-73256 as a function of time (Julian Date)

experiment the phase is defined as the fraction of the orbital period that has elapsed. The radial velocity of the stars (HD-28185 and HD-73256) as a function of phase was then plotted, as seen in figure 2. This allowed for a more accurate representation of the radial velocity of the stars as a function of time, as the time between observations was more consistent.

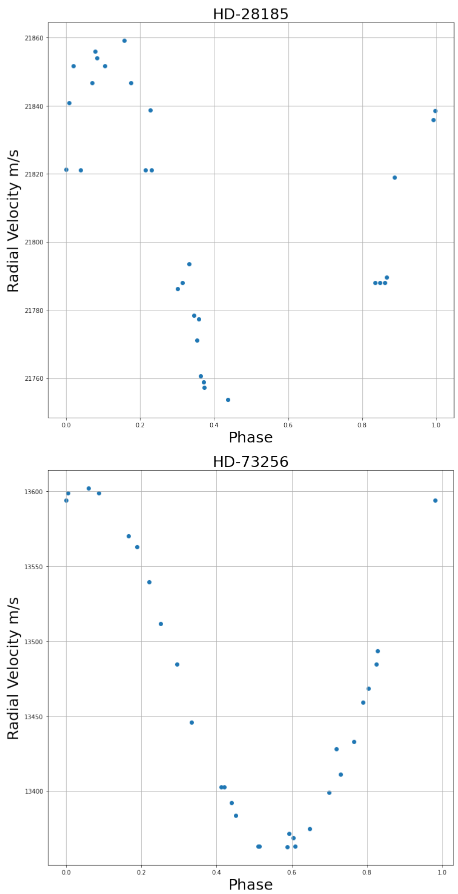

Figure 2: Radial velocity of HD-28185 and HD-73256 as a function of phase

Now that there was a clear correlation between the radial velocity of the stars and time, it was possible to calculate characteristics about the extra-solar planets in orbit around the stars (HD-28185 and HD-73256) using By using the data calculated so far in this report it was possible to now calculate the mean radial velocity v_{mean}, the amplitude of the radial velocity curve v_s and the phase when the radial velocity curve is at a maximum ϕ_{max} of the stars. As well as the associated covariance matrix uncertainties for each of these values.

For the stars (HD-28185 and HD-73256) the values obtained for v_{mean}, v_s and ϕ_{max} were.

Table 1: Radial velocities and Phase of stars HD-28185 and HD-73256.

	HD-28185	HD-73256
v_{mean}	$2.18 \times 10^4 \pm 4.00ms^{-1}$	$1.35 \times 10^4 \pm 2.80ms^{-1}$
v_s	$67.6 \pm 6.16ms^{-1}$	$1.20 \times 10^2 \pm 3.92ms^{-1}$
ϕ_{max}	$8.59 \times 10^{-2} \pm 0.01$	$5.73 \times 10^{-2} \pm 0.01$

Values of ϕ_{max} are dimensionless in this instance as they are fractions of the orbital periods.

Now that values for v_{mean}, v_s and ϕ_{max} of both stars have been calculated, it was possible to determine the mass and semi-major axis of the extra-solar planets in orbit around the stars (HD-28185 and HD-73256). The mass of the planets was calculated using where the mass of the planet m_p is dependent on the amplitude of the radial velocity curve v_s, the mass of the star M_s and the period of the orbit of the planet T. As the mass of the parent star had not been calculated previously it was necessary to make an educated assumption of what this mass might be. Therefore based on the idea that these stars share similar properties to the sun it was assumed that the mass of the parent stars was $M_s = 1.0M_{\odot}$. Then using it was possible to calculate the semi-major axis of the planets in orbit around the stars (HD-28185 and HD-73256). The values for the mass and semi-major axis of the relevant planets around each star are shown in table 2, with the associated uncertainties progated from the uncertainties in the values of v_{mean}, v_s and T.

Table 2: Mass and semi-major axis of planets in orbit around stars HD-28185 and HD-73256.

	HD-28185	HD-73256
m_p	$1.7654 \pm 0.1089 \times 10^{25}kg$	$1.0517 \pm 0.0413 \times 10^{26}kg$
a	$2.2756 \pm 0.1365 \times 10^6m$	$2.5446 \pm 0.1018 \times 10^7m$

Method

For the Doppler Wobble method it was first necessary to import all the data provided into a directory that could be accessed by the code source files. From here it was possible to start writing the Python script that would take the data and produce the required outputs as outlined in the aims above.

Results

For doppler wobble method 1.1 result is graph.

1.2 radial velocity of both stars on all dates

1.3 plot radial velocity as a function of time, calculate the phase of each star and plot the radial velocity as a function of phase

1.4 calculate values of v_{mean} v_s and ϕ_{max} and determine errors, for both stars

1.5 calculate the mass of each planet and the semi-major axis of each planet with errors

Analysis

Introduction and Background

Aims

Obtain a phase-folded photometric light curve for a star with a transiting planetary companion. Use this to estimate the radius and orbital semi-major axis of the planet Apply the method of least-squares to estimate mean apparent magnitudes during the transit and non-transit phase. Hence estimate the radius of the planet.[1]

Method

Results

Analysis

Conclusion

References