Planets and Exoplanets 2010: Exercises to Lecture 5
Due: 26 October 2010 at 13:15

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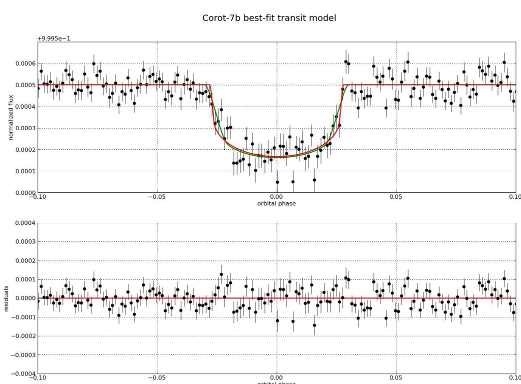
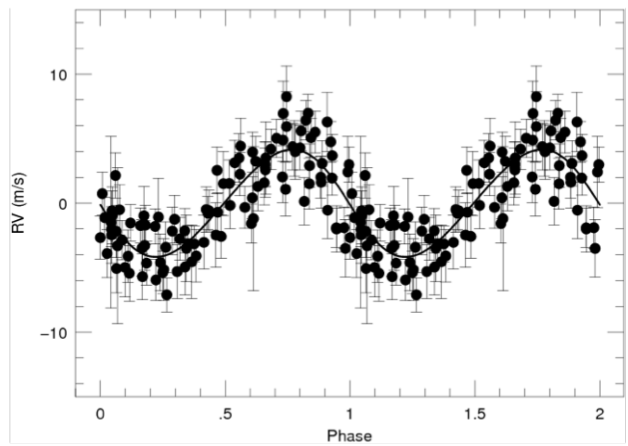
1 Introduction

In this exercise, you will carry out a series of calculations to determine the star-exoplanet distance, the mass, radius, and then the density of the Corot-7b exoplanet, the first rocky exoplanet discovered. We will assume a circular orbit, which is compatible with the observed radial velocity variations.





The transient observations were obtained with Corot and reported by Léger et al. (2009, see http://adsabs.harvard.edu/abs/2009A%26A...506..287L). The central star is of spectral type G9V, has an age of 1.2 to 2.3 Gyr and is located at a distance of 150 ± 20 pc from Earth. On the left is a copy of their figure 17 showing the observed transit lightcurve and their fits to it.

The radial velocity data were obtained with HARPS and reported by Queloz et al. (2009, see http://www.aanda.org/articles/aa/pdf/forth/aa13096-09.pdf). Below is a copy of their Figure 9 showing the observed radial velocity data together with a sinusoidal fit.

The table lists the quantities, extracted from those two papers, that you will need for these exercises.

quantity	value	unit
solar radius	109	Earth radii
solar mass	332900	earth masses
Jupiter mass	318	earth masses
stellar mass	0.93 ± 0.03	solar masses
stellar radius	0.87 ± 0.04	solar radii
orbital period	$0.853585 \pm 24 \cdot 10^{-6}$	days
relative flux change	$3.35 \cdot 10^{-4} \pm 0.12 \cdot 10^{-4}$	
radial velocity amplitude	3.5 ± 0.6	m/s

2 Exoplanet distance

Determine the distance between the star and the exoplanet in Astronomical Units (1 AU = mean distance between Sun and Earth). Compare your result to the orbit of Mercury in our solar system.

3 Radius ratio from lightcurve

Determine the ratio of exoplanet to stellar radius from the depth of the eclipse.

4 Exoplanet radius from lightcurve

Assuming an inclination of 90 degrees, determine the stellar radius from the duration of the eclipse. Why does it not agree with the value listed in the table above?

Determine the exoplanet's radius in Earth radii assuming the stellar radius listed in the table.

5 Radial velocity variation and amplitude

Show that a circular orbit with an inclination of 90 degrees leads to a sinusoidal variation of the radial velocity.

6 Exoplanet mass

Determine the planet's mass in Earth masses from the observed radial velocity amplitude and the stellar mass assuming a circular orbit.

7 Exolanet density

Calculate the planet density from the mass and radius determined above. Compare your findings with the densities of solar-system planets.

8 Bonus Exercise: Error Propagation

The quantities that are used to calculate the density are not precise. Which quantity is responsible for the largest error in the density estimate?