A Spitzer Secondary Eclipse Observation of HD 209458b at 16μm with IRS.

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INTRODUCTION

When transiting extrasolar planets pass behind their stars (secondary eclipse), one can measure their day-side emission. These secondary eclipses allowed measurements of the first photons from exoplanets (Deming et al. 2005, Charbonneau et al. 2005), and constrain orbital and atmospheric properties such as temperatures.

HD 209458b, the first transiting exoplanet discovered (Charbonneau et al. 2000), has been studied extensively and is found to have a clear inversion layer in the upper atmosphere (Knutson et al., 2008). The Knutson et al. 2008 paper reported observations of eclipses in the 4 IRAC channels at shorter wavelengths, while Deming et al. 2005 reported an eclipse in the 24μm MIPS channel. As part of the Spitzer Exoplanet Target of Opportunity program, in December of 2005, we obtained photometric data of HD 209458 during a secondary eclipse, using the IRS blue peak-up array at 16μm.

DATA ANALYSIS

The telescope nodded among 4 positions over the array. The detector presented a hot pixel at a distance of 3.5 pixels from the center of one of our positions (Figure 1). We begin our analysis from Spitzer's basic calibrated data performing interpolated aperture photometry with aperture radii from 2.5 to 6 pixels. For aperture radii larger than 3 we processed only the three uncorrupted positions. There was an increasing time-dependent pixel sensitivity effect (a feature of this instrument known as the "ramp effect"). We also observed different flux levels at the different positions. Figure 2 shows the raw light curve of the system for an aperture radius of 5.25 pixels.

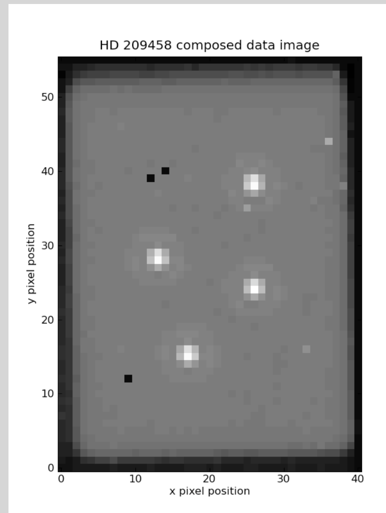

Figure 1:
The four nodding positions of HD 209458, superposed on the same image. The array presents a hot pixel located at a distance of 3.5 pixels from the center of the target at the upper right position, corrupting the data for aperture radii including part of that pixel.

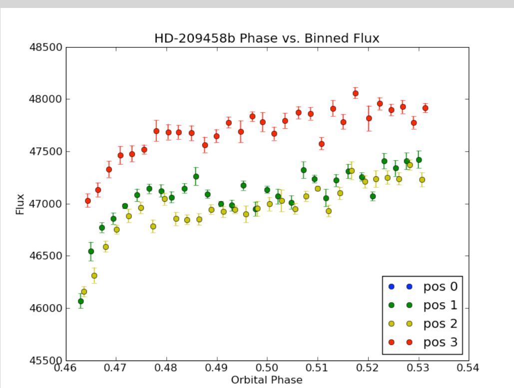

Figure 2:
Light curve of HD209458 for an aperture size of 5.25 pixels. Position 0 is discarded due to the presence of a hot pixel. The ramp effect can be seen, along with the distinct sensitivities at each of the three remaining positions.

We then modeled the resulting light curve using a Markov-chain Monte Carlo (MCMC) routine, fitting parametrized functions of the eclipse (Mandel & Agol, 2002), the ramp curve, and the per-position flux level, simultaneously. We modeled the ramp effect with combinations of linear, exponential, and/or logarithmic functions. The selection of the most appropriate aperture radius is based on the fit that minimizes the scatter of the residuals, while the minimum value of the Bayesian Information Criterion indicates the best fitting models. Figure 3 shows one of the model fits.

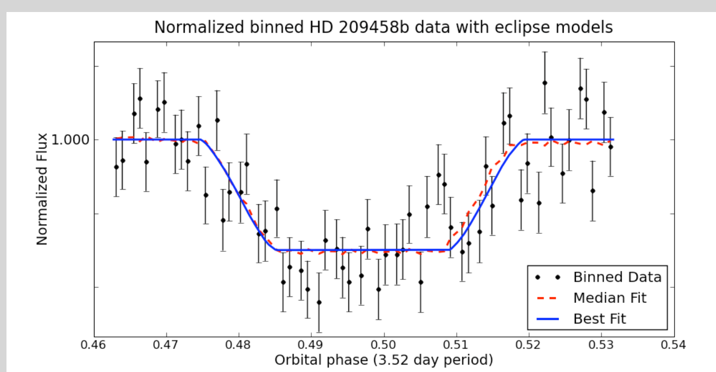

Figure 3:
Normalized light curve of the secondary eclipse of HD 209458, modeled with an exponential ramp function. From the MCMC routine we obtain the eclipse depth along with other parameters of the planet.

UP NEXT

The complete eclipse modeling is currently a work in process. Once we have obtained the eclipse depth at 16μm, the value will be analyzed in combination with other Spitzer secondary eclipse measurements from the literature (Figure 4), to characterize HD 209458b's atmosphere and investigate the presence of its inversion layer and chemical composition.

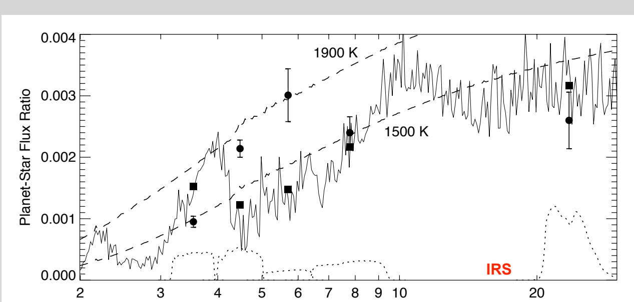

Figure 4:
Theoretical model of the emission spectrum of HD 209458b. The circles show measured values and the squares show theoretical model spectrum values integrated over the Spitzer bands (bottom dotted lines), plot from Knutson et al. 2008.

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