Transmission spectra of the possibly disintegrating planet KIC 12557548b

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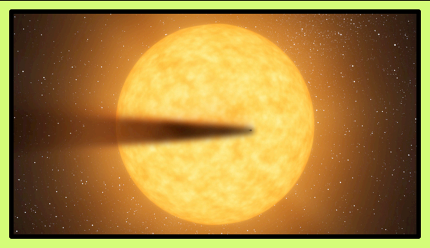

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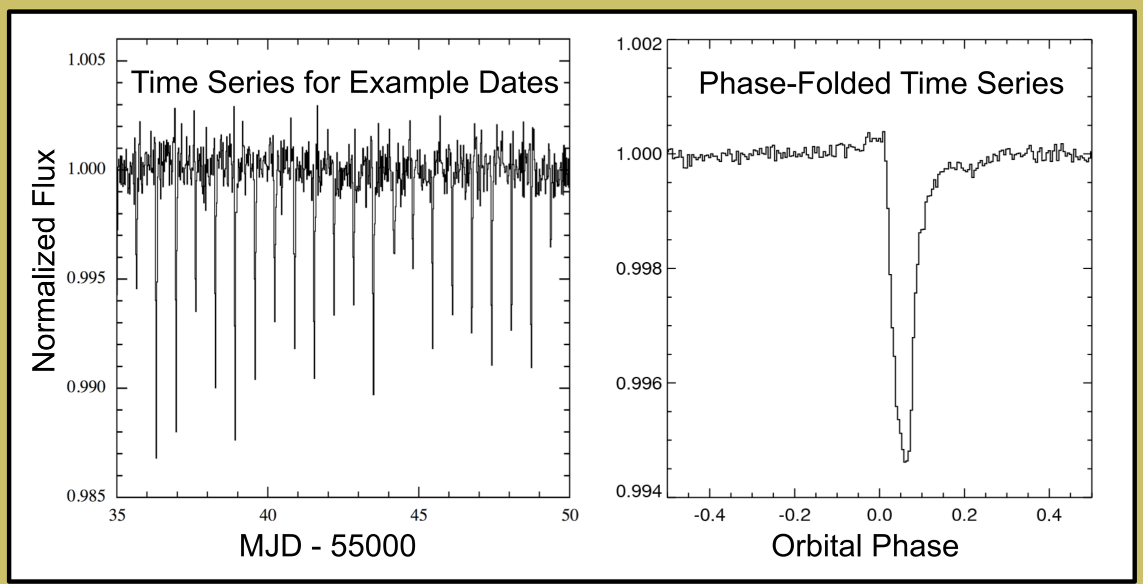
1 Introduction

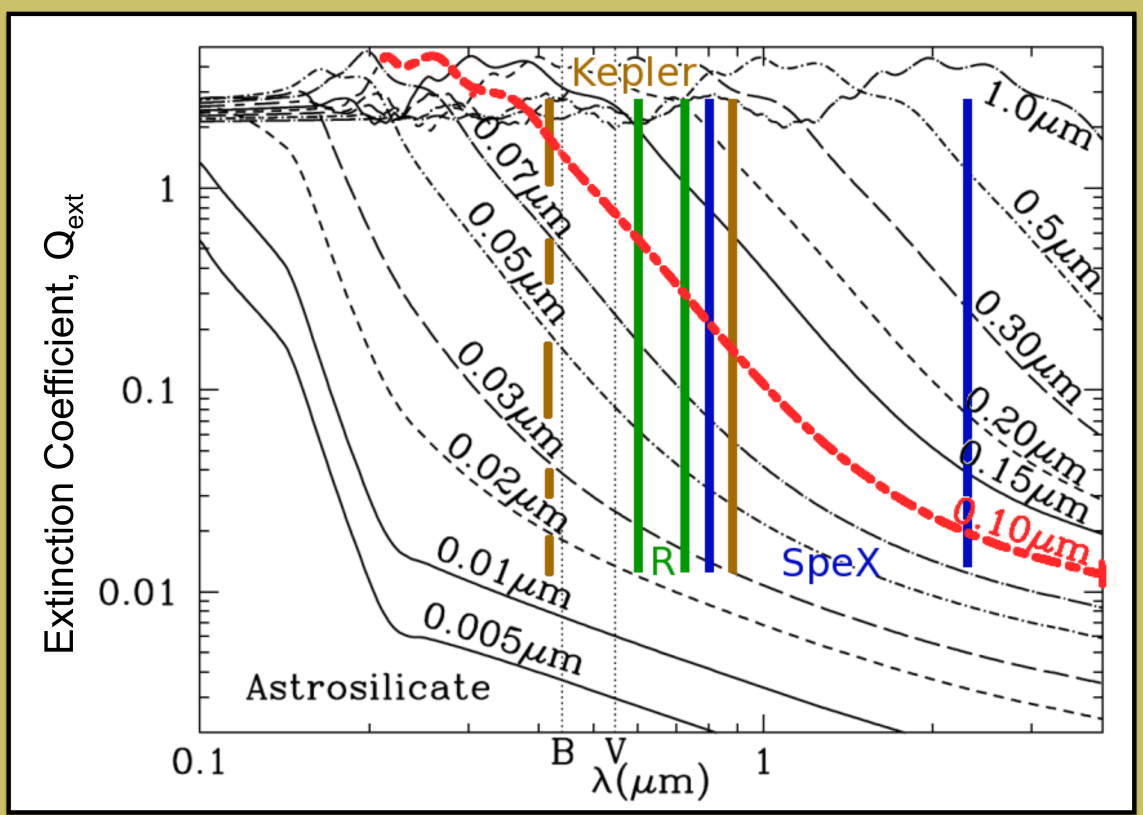
We present spectroscopic observations of the KIC 12557548 system, which is hypothesized to have a disintegrating planet with a mass less than 0.1 M_{Earth} [2]. KIC 12557548b was discovered by the NASA Kepler mission, which monitored over 150,000 stars with high precision photometry[3]. The broadband optical transit depths vary from ~0.2% to ~1% in strength but with a constant orbital period. This is in contrast to escaping winds from hot Jupiters, which are transparent in broadband optical light and can only be detected at narrow atomic or ionic absorption lines [4]. The broad spectral nature of the transit depths indicates that the material may be composed of solid particles. Of all the scenarios proposed to explain the system, the most likely is that it is an evaporating rocky planet[2].

2 Kepler Light Curves



Left: A portion of the full Kepler light curve[2] shows that the transit depth varies from transit to transit. The planetary debris may be quickly created and/or destroyed on ~1 day timescales.
Right: The phase-folded light curve from the short cadence data[5] is asymmetrical and has a small increase in flux prior to transit likely from scattering by dust. Scattering models for the planetary debris give particle size estimates of 0.1µm [6].

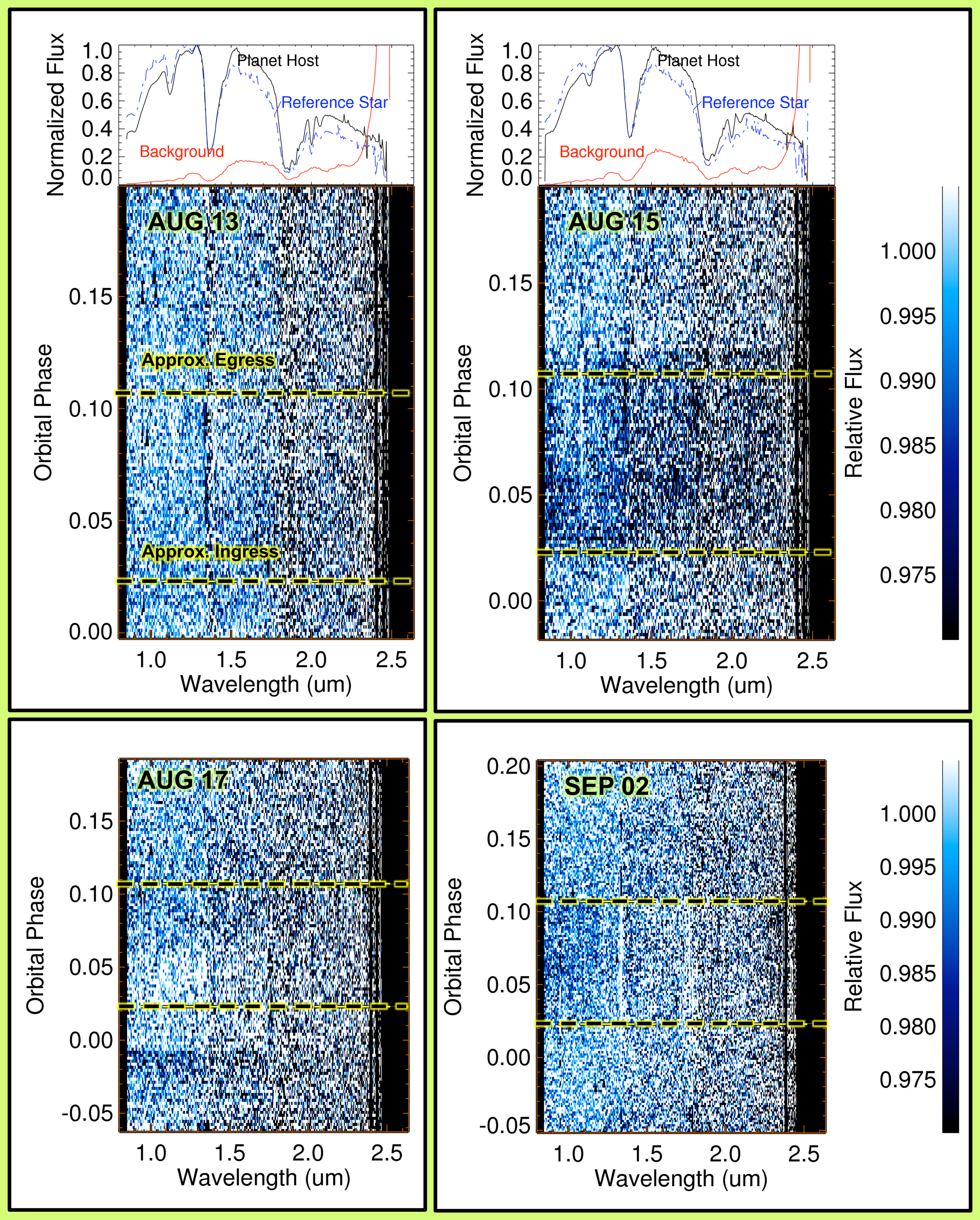
3 Prediction



If the planet's escaping debris are ~0.1µm sized dust particles[6], they should cause stronger optical extinction than infrared extinction when the planet transits its host star. Extinction coefficients as a function of wavelength for silicate spheres are shown with labels for grain radius[7]. The wavelength coverage for Kepler (brown), the *r'* band imager (green) and SpeX imager (blue) are shown with vertical lines. The 0.1µm curve (which is the expected particle size[6]) is highlighted in red. In the case of optically thin extinction and a single particle size, the extinction curve is proportional to transit depth.

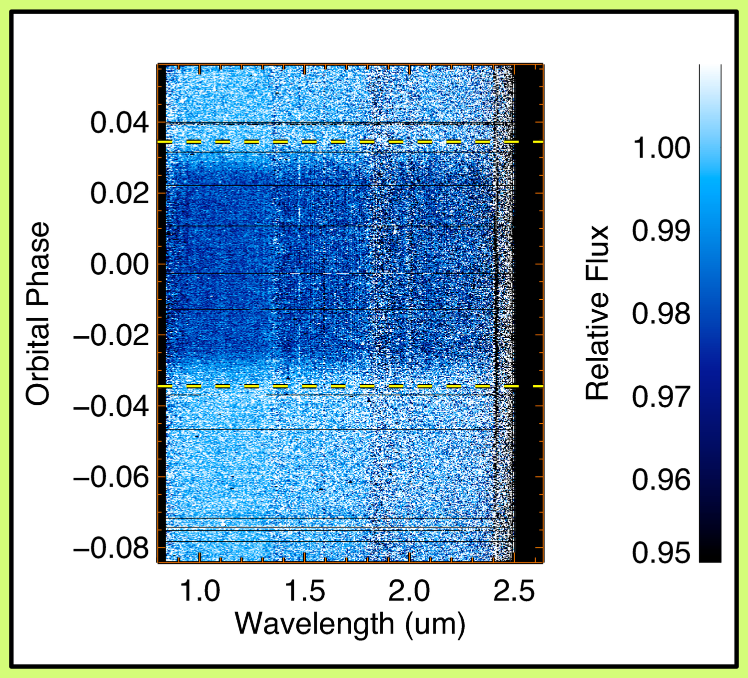
4 SpeX and MORIS Observations

We observed KIC 12557548 with the SpeX and MORIS instruments on the NASA IRTF for four transits. We divide KIC 12557548's spectrum by a reference star (2MASS J19234770+5130175) to correct for variations in telluric transmission and response of the instrument.



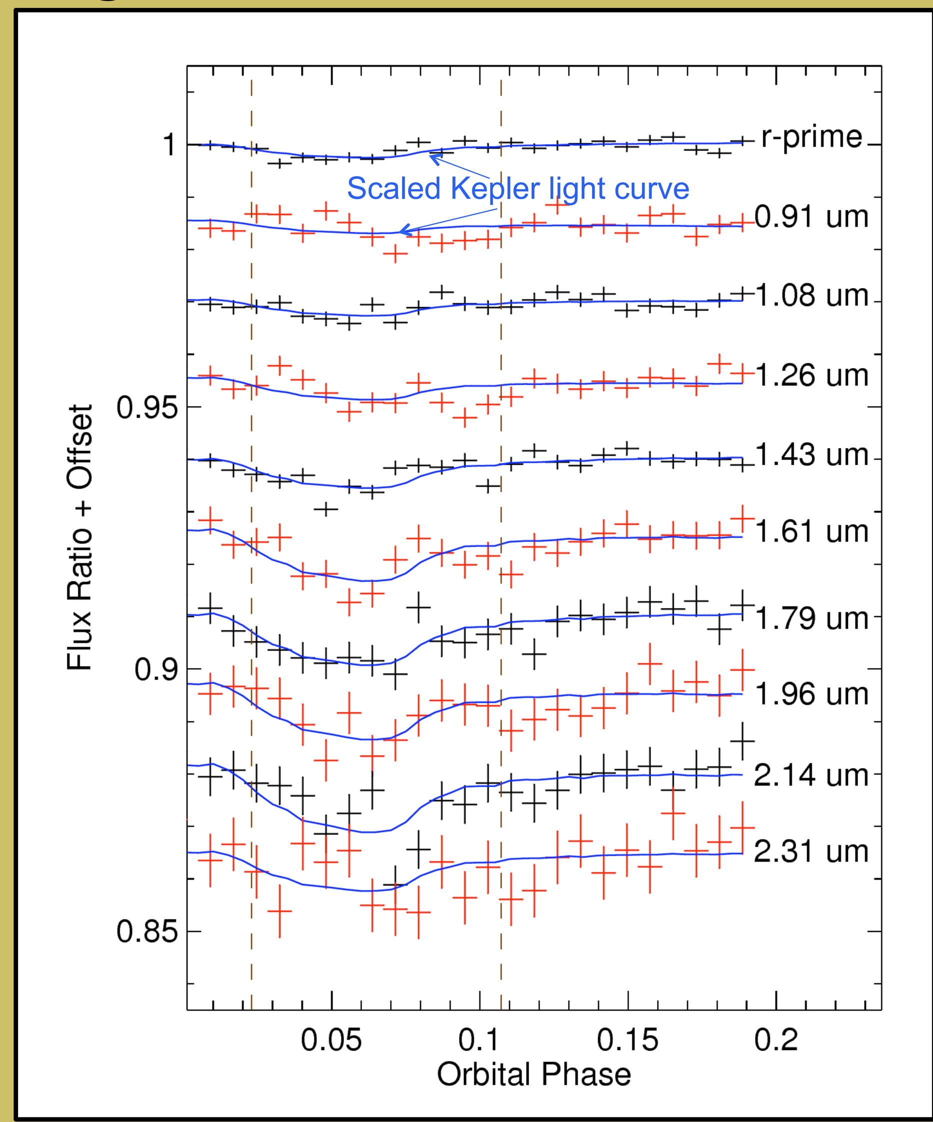
Top Panels: Raw spectra for KIC 12557548 and reference star show where telluric absorption lowers the signal. Thermal emission causes the dramatic rise in background for λ > 2.4µm
Bottom 4 Panels: Dynamic spectra of KIC 12557548 for the four transits of UT dates August 13, 15, 17 and September 02, 2013. The transits vary in depth and spectral shape in the infrared wavelengths of 0.8µm to 2.5µm. Horizontal yellow dashed lines indicate the approximate ingress and egress of system's transit from the Kepler phase-folded light curve.

5 Comparison Spectrum



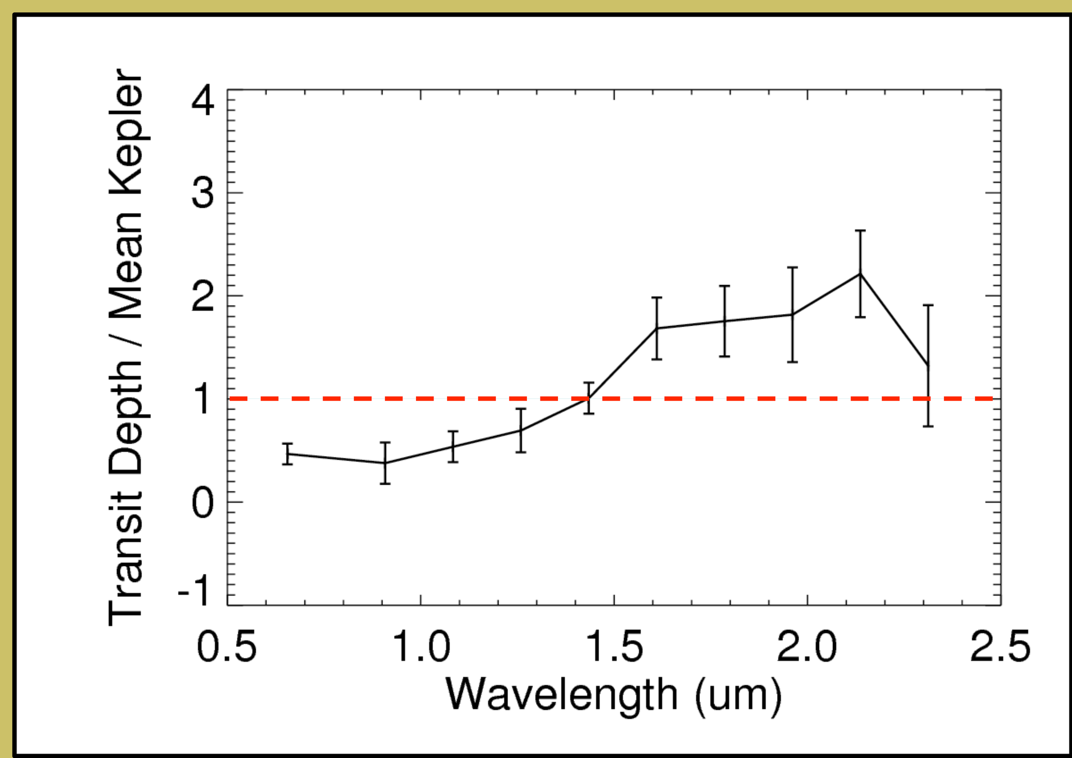
The efficacy of the same observational technique is shown left for the hot Jupiter CoRoT-1b. This dynamic spectrum was taken on January 4, 2012 [8], also with SpeX. In this case, the reference star and target star are brighter, *K*=11.5 and 12.1, whereas the analogs for KIC 1255748 are *K*=14.0 and 13.3. The 1.9% transit depth for CoRoT-1b is also easier to detect than KIC 12557548b's variable transit depths (~0.2% to ~1%).

6 Average Time Series



Time series for the all nights combined for 0.17µm-wide wavelength bins with the SpeX spectrograph and the simultaneous *r'* filter photometry with the MORIS imager. The *r'* optical light curve shows a smaller transit depth than the SpeX infrared light curve. The phase-folded Kepler light curve (blue) is scaled to give a best fit for a given wavelength bin.

7 Light Curve Fits



The phase-folded Kepler light curve (Box 2) is linearly scaled from its mean value to fit the time series observed with SpeX and MORIS for each transit. The red dashed line demarcates the 1:1 ratio between the SpeX and Kepler transit depths; the mean Kepler depth is 0.5%. In contrast to the prediction for dust extinction (Box 3), KIC 12557548b's transit depth is not systematically smaller in the infrared relative to the optical. A possible explanation is that dense molecular gas from the planet absorbs the infrared but not optical light.

8 References

[1]Image Credit http://www.jpl.nasa.gov/news/news.php?release=2012-141
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[7]Draine, Physics of the Interstellar and Intergalactic Medium (2011)
[8]Schlawin et al. *The Astrophysical Journal*, submitted

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