# Atmospheric Study of the Hot Uranus GJ3470b via Multi-band Simultaneous Photometry

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GJ3470b is a low-mass (~14 $M_\oplus$) transiting planet orbiting a nearby (~35 pc) M dwarf [1]. Although this planet is only 4 times the size of the Earth, because the host star is also small, with about half the size of the Sun, the system shows a relatively large transit depth. In addition, the closeness to the system makes the host star bright, allowing us to investigate the nature of the system in detail. Especially, for such a system, we can probe planetary atmospheric composition by measuring transit depth (i.e., square of planet-to-star radius ratio) as a function of wavelength. GJ3470b is the second lightest planet among such atmospheric-researchable planets, and therefore it is an important target to study the atmospheric nature of low-mass planets.

In this research, we conducted multi-band transit observations of GJ3470b to study its atmosphere by using the 188-cm and 50-cm telescopes both at Okayama Astrophysical Observatory. We used the near-infrared imaging and spectroscopic instrument ISLE with $J$-band (~1.3 $\mu$m) filter which is mounted on the 188-cm telescope, and an optical three-band simultaneous imager mounted on the 50-cm telescope which enables to obtain g′ (~500 nm), $R_c$ (~650 nm), and $I_c$ (~800 nm) band images simultaneously. At $J$ band, thanks to the high performance of the 188-cm telescope/ISLE and also thanks to the fact that the host star is especially bright in infrared because of its low temperature, we achieved a high-photometric precision of ~1 mmag level (Figure 1).

Comparing the observed apparent planetary radii across different passbands including the one at 4.5-$\mu$m band obtained by *Spitzer* space telescope [2], we find that the planetary radius in $J$ band is smaller than those in other wavelengths (Figure 2). This result can naturally be explained by a hydrogen-dominated and hazy atmospheric model. On the other hand, if the planet was covered by thick clouds, light of any wavelengths would be equally scattered by the clouds, and so the observed radii would not depend on wavelength. Therefore, our results indicate that this planet is probably not covered by thick clouds [3]. If true, future detailed observations of this planet will detect many molecular features in its atmosphere without being prevented by clouds.

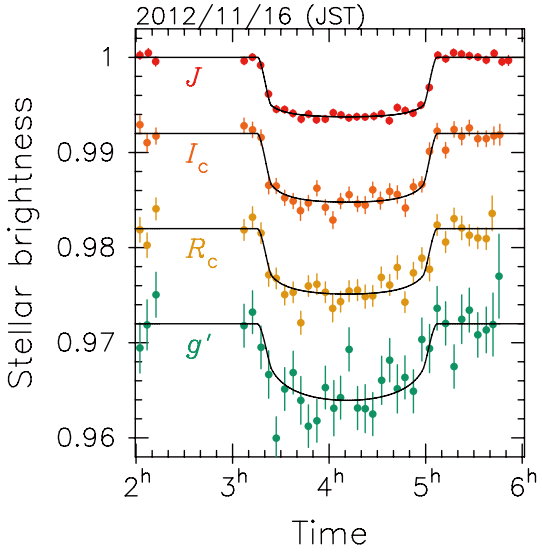


**Figure 1**: Transit light curves of GJ3470b obtained by the two telescopes at Okayama Astrophysical Observatory. The top (red) plot indicates the data from the 188-cm telescope/ISLE, while the bottom three (orange, yellow, and green) indicate those from the 50-cm telescope.

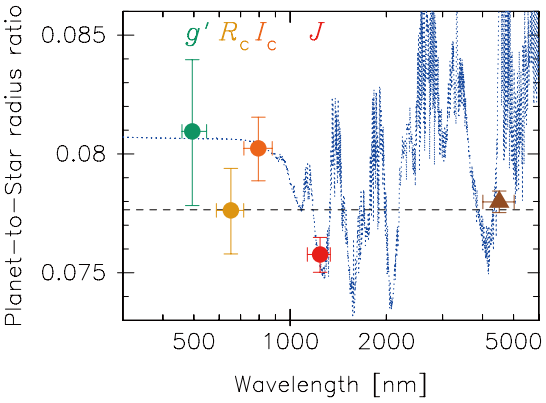


**Figure 2**: Planetary radius (shown in planet-to-star radius ratio) of GJ3470b as a function of wavelength. The circles are the data obtained in this research, while the triangle is the data in 4.5-$\mu$m band obtained by Spitzer [2]. The blue dotted line indicates a hydrogen-dominated and hazy atmospheric model, while the black dashed line indicates a thick-cloud atmospheric model.

## References

[1] Bonls, X., et al.: 2012, *A&A*, **546**, A27.
[2] Demory, B.-O., et al.: 2013, *ApJ*, **768**, 154.
[3] Fukui, A., et al.: 2013, *ApJ*, **770**, 95.