Looking into the Sky of a Super-Earth

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Super-Earths are emerging as a new type of exoplanet with a mass and radius larger than the Earth's but less than those of ice giants in our Solar System, such as Uranus or Neptune.

Current theories explain that a planet forms in a protoplanetary disk. Hydrogen is a major component of a protoplanetary disk, and water ice is abundant in an outer region beyond a so-called “snow line.” Findings about where super-Earths have formed and how they have migrated to their current orbits point to the prediction that hydrogen or water vapor is a major atmospheric component of a super-Earth. Thus if one can determine the major atmospheric component of a super-Earth, one can then infer the planet’s birthplace and formation history.

Planetary transits enable us to investigate changes in the wavelength in the depth of dimming of the stellar brightness (i.e., transit depth), which provide information about the planet’s atmospheric composition. This methodology is referred to as transmission spectroscopy (see figure 1).

We focused on investigating the atmospheric features of one super-Earth, GJ 1214 b, which is one of the well-known super-Earths discovered by the MEarth Project. We used the two optical cameras Suprime-Cam and FOCAS on the Subaru 8.2 m Telescope and the SIRIUS camera on the IRSF 1.4 m telescope to see the feature of GJ 1214 b’s atmosphere.

Our observations showed that GJ 1214 b’s atmosphere does not display strong Rayleigh scattering ([1,2]: see figure 2). This finding implies that the planet has a water-rich atmospher or a cloud-covered atmosphere.

Although there are only a small number of super-Earths that astronomers can observe in the sky now, this situation will dramatically change when the Transiting Exoplanet Survey Satellite (TESS) begins its whole sky survey of small transiting exoplanets in our solar neighborhood. When new targets become available, we can study the atmospheres of many super-Earths. Such observations will allow us to learn even more about the nature of various super-Earths.

References

[1] Narita, N., et al.: 2013a, *PASJ*, **65**, 27.
[2] Narita, N., et al.: 2013b, *ApJ*, **773**, 144.

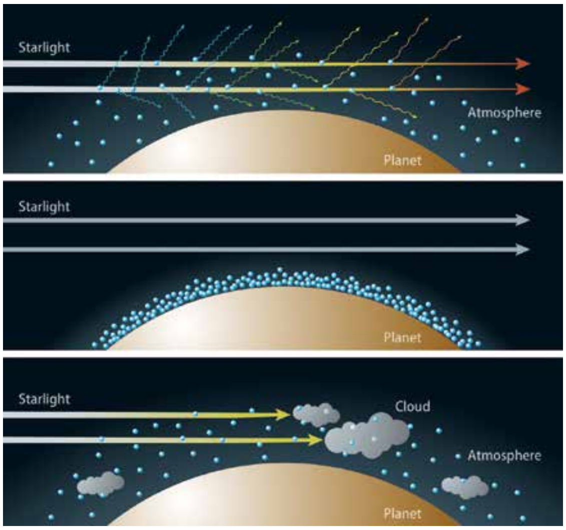

Figure 1: An illustration of the relationship between the composition of the atmosphere and transmitted colors of light. Top: If the sky has a clear, upward-extended, hydrogendominated atmosphere, Rayleigh scattering disperses a large portion of the blue light from the atmosphere of the host while it scatters less of the red light. Middle: If the sky has a less extended, water-rich atmosphere, the effect of the Rayleigh scattering is much weaker than in a hydrogen-dominated atmosphere. In this case, transits in all colors have almost the same transit depths. Bottom: If the sky has extensive clouds, most of the light cannot be transmitted through the atmosphere, even though hydrogen dominates it. As a result, transits in all colors have almost the same transit depths. (Credit: NAOJ)

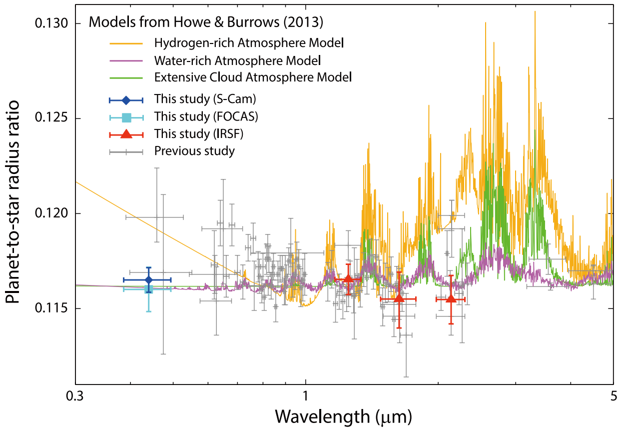

Figure 2: Observed transit depths and theoretical models for GJ 1214 b (based on [2]).