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題目(和文)	Studies of hot Jupiter atmospheres with high-resolution transmission spectroscopy
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Recently, the small exoplanets such as terrestrial planets have a lot of attention; however, the variety and classified of hot Jupiter atmospheres are not still revealed because the observations of hot Jupiter atmosphere are not so much. Na is important to investigate the opacity in the planetary atmosphere since the Na absorption lines absorb almost all of the incoming stellar irradiation in optical. Especially, Na absorption lines with high-resolution spectroscopy is also important to investigate the atomic escape affecting the evolution of the exoplanets owing to reflect the environment in upper atmosphere.

In addition, the observed transmission spectra in very-hot Jupiters is different to prediction from equilibrium temperature with Fortney et al. 2010. It was considered that the features of TiO/VO were large and hid the other absorption features in very-hot Jupiter. However, Na and/or haze feature are detected in a few very-hot Jupiters. With high-resolution transmission spectroscopy, Na absorption lines were detected for WASP-12 and MASCARA-2b; however, these absorptions are different. MASCARA-2b is a peculiar case because its host star is A-type star, the planetary mass is large, the semi-major axis is the largest in the hot Jupiters detected Na absorption lines with high-resolution spectroscopy in spite of very-hot Jupiter. It is difficult to compare these two planets since they have many different parameters. It is important to investigate very-hot Jupiters which have almost same parameters owing to investigate the reason of the different absorptions.

We observed a well-known planet, HD189733 on 2009/07/12 (UT) and a new very-hot Jupiter, WASP-76 on 2018/09/10 (UT) with Subaru HDS to detect the Na D absorption lines in the atmosphere because we establish an analysis method with Subaru/HDS and check the existence of atmospheric Na absorption in new very hot Jupiter around F-type star which is same spectral type with WASP-12. These observed data have telluric absorption lines, stellar absorption lines, and the instrumental profile in addition to the absorption lines of the exoplanetary atmosphere. We carefully removed the unnecessary spectra and instrumental profile from the Subaru/HDS data and were able to detect Na D absorption lines in both planetary atmospheres.

For HD18933b, the detected Na D1 line had a line contrast of 0.38 ± 0.03, an FWHM of 0.99 ± 0.06, and an EW of 0.40 ± 0.03, and the detected Na D2 line had a line contrast of 0.51 ± 0.03, an FWHM of 0.88 ± 0.05, and an EW of 0.48 ± 0.03. These results show that the Na D absorption lines are shallower and broader than those in previous work, but the EWs are similar to or slightly larger than those in previous work. The absorption signals over the same passband are also consistent with those in previous work. In addition, each Na D line was compared with the isothermal model spectra. The model spectra at the equilibrium temperature (1400 K) were not fitted and were best fitted at T = 3000^{+140}_{-220} K (Na D1) and T = 2900^{+180}_{-190} K (Na D2). These results were consistent with Huitson et al. (2012) and Wyttenbach et al. (2015).

For WASP-76b, the detected Na D1 line had a line contrast of 0.38 ± 0.03, an FWHM of 0.99 ± 0.06, and an EW of 0.40 ± 0.03, and the detected Na D2 line was large but was not able to be fit by a Gaussian since the stellar variation was large in the line core and/or the shape was not matched with a Gaussian. The absorption signals over the same passband are larger than those of HD189733b, and the gradient of the absorption signals with a passband was gentler than that of HD189733b. Compared with six other planets, there was strong absorption in the line core, as for MASCARA-2b, WASP-49b, and WASP-69b, and the gradient of the absorption signals with passband were the gentlest for the observed planets. These results indicate that there is less Na depletion caused by an ionized stellar flux (Brown 2001, Barman 2007) and/or a condensate on the night side (Iro, Bezard & Guillot 2005) than WASP-12b, WASP-17b, and HD209458b and not many clouds and/or much haze in the observation range (Fortney et al. 2003).

In an atmosphere over 2000 K, the TiO signal hides the Na D lines (Fortney et al. 2010). However, if TiO has subsolar abundance, there are both TiO spectra and Na D lines like WASP-19b (Sedaghati 2017). Therefore, we cannot indicate the nonexistence of TiO but can indicate the nonexistence of TiO of solar abundance. In addition, the best-fitted isothermal mode spectra correspond to T = 3700^{+202}_{-154} K (Na D1) and T = 4000^{+163}_{-207} K (Na D2) on the assumption of an atomic layer. These results suggest the existence of a thermosphere. To investigate the condition of the atmosphere (e.g., the temperature structure), we will investigate other absorption lines with high-resolution spectroscopy. Now, we already observed the K absorption lines; therefore, this is planned for future work.

Two very-hot Jupiters, WASP-12b and MASCARA-2b are different Na absorption in the line core. Our target, WASP-76b orbits around a same spectral type of the host star with WASP-12b and has parameters close to those of WASP-12b compared to MASCARA-2b. However, the Na absorptions for WASP-76b are different with those for WASP-12b. To reveal this problem, we should correct the various contaminants such as the variation in the stellar spectrum (RM effect and CLV effect) and the planet orbital velocity in our data and reanalyze our data to detect the wind velocity in upper exoplanetary atmosphere which is important in order to investigate a gradient between the day and night temperatures. We should also observe WASP-76b with low-resolution spectroscopy to investigate the existence of clouds and/or haze. In this work, we found that the Na absorptions detected with high-resolution spectroscopy were different even if these planets have similar parameters and revealed the variety of hot Jupiter.