論文 / 著書情報
Article / Book Information

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種別(和文)	論文要旨
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論 文 要 旨

THESIS SUMMARY

専攻： Department of	地球惑星科学	専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	（ 理学 ）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Recent observations have found a number of hot Jupiters, which are gas planets orbiting near a star and do not exist in the solar system. To reveal the formation scenario of hot Jupiters, it is necessary to gain insights into the structure and composition of the planetary atmosphere, which is susceptible to extraneous factors. In particular, alkali metal lines are one of the most important key opacity sources because the Na I resonance doublets are thought to be the cause of the generally low albedos, as the alkali metal's wide line wings absorb almost all of the incoming stellar irradiation.

In the last two decades, the understanding of exoplanetary atmospheres has advanced considerably through spectroscopic observations during planetary transit events. Recently, by low-resolution transmission spectroscopy with the Hubble Space Telescope (HST), alkali metals have been searched for in eight hot Jupiter atmospheres, which have a relatively large range of planetary equivalent temperatures. These results reveal that the strengths of the observed alkali metal lines are different from planet to planet. The reasons for these differences are high clouds or hazes, a low alkali abundance, and nonlocal thermal equilibrium effects.

Considering the case where alkali metal lines cannot be detected owing to clouds or haze, these signals become small with low-resolution transmission spectroscopy. However, weak signals originating from the atmosphere above clouds or haze exist. We can distinguish the contribution of each factor by observing the alkali metal lines with high-resolution transmission spectroscopy, which can detect weak signals. High-resolution transmission spectroscopy can also investigate the temperature in the upper atmosphere of planets. It is important to investigate the temperature structure in order to understand hot Jupiters because it can reveal the thermal cycling and lead to the understanding of the temperature evolution process after planet generation.

Hot Jupiters are roughly classified into two types the basis of the equilibrium temperature of planets. In particular, for a ``very-hot Jupiter'' whose equilibrium temperature is over 2000 K, it is predicted that the TiO/VO absorption is dominant in the optical wavelength region and the Na absorption lines cannot be detected. However, contrary to the prediction, the existence of TiO/VO has been confirmed in only one very-hot Jupiter. Moreover, Na absorption lines were detected for one and two very-hot Jupiters with low-resolution transmission spectroscopy and high-resolution transmission spectroscopy. These results indicate that the atmospheric composition cannot be explained by this classification only. We need to further study hot Jupiters with various planet properties in order to understand their atmospheres.

We performed high-resolution transmission spectroscopy for HD189733b and WASP-76b with the Subaru 8.2 m telescope and the High Dispersion Spectrograph (HDS). HD189733b is a well-studied hot Jupiter; thus, we use this planet for the purpose of establishing the analysis method for Subaru/HDS. WASP-76b is a very-hot Jupiter for which high-resolution transmission spectroscopy has never been performed.

For HD189733b, we detected Na absorption lines and measured line contrasts of 0.38 ± 0.03 (Na D1) and 0.51 ± 0.03 (Na D2), FWHMs of 0.99 ± 0.06 (Na D1) and 0.88 ± 0.05 (Na D2), and EWs of 0.40 ± 0.03 (NaD1) and 0.51 ± 0.03 (Na D2). The line contrasts and FWHMs are inconsistent, but the EWs are consistent with previous work. We also derived the temperatures of the upper atmosphere as 3000^{+140}_{-220} K (Na D1) and 2900^{+180}_{-190} K (Na D2) and the Na absorption signals by integrating over various passbands. These values are in agreement with previous work.

For WASP-76b, we detected strong Na D absorption lines and measured a line contrast of 0.38 ± 0.03 (Na D1), an FWHM of 0.99 ± 0.06 (Na D1), and an EW of 0.40 ± 0.03 (Na D1). The Na D2 line was not able to be fitted by a Gaussian profile since the stellar variability was large in the line core and/or the line shape was not matched with a Gaussian. We derived the temperatures of the upper atmosphere as 3700^{+202}_{-154} K (Na D1) and 4000^{+163}_{-207} K (Na D2) on the assumption of an atomic layer where an atomic hydrogen is dominated. We also integrated the absorption signals over various passbands. The absorption signals in the narrow passband were about 1.5 times larger and those in the broad passband were about 2.3 times larger than those of HD189733b.

Compared with seven hot Jupiters (HD209458b, HD189733b, WASP-17b, WASP-69b, WASP-49b, WASP-12b, and MASCARA-2b), for which high-resolution transmission spectroscopy has already been performed, after rescaling by the WASP-76b scale height, we found that there is strong absorption in the line core, which is consistent with four planets (HD189733b, WASP-69b, WASP-49b, and MASCARA-2b), and WASP-76b shows the largest absorption signal in the broad passband. These results suggest that there is litte Na depletion caused by an ionized stellar flux and/or a condensate on the night side, not many clouds and/or much haze in the observation range, and the possibility of the existence of a thermosphere.