On the Indirect Detection of Sodium in the Atmosphere of the Planetary Companion to HD 209458b
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abstract

We construct a new model of the atmosphere of the transiting extrasolar giant planet HD 209458b to investigate the disparity between the observed strength of the sodium absorption feature at 589 nm and the predictions of previous models. Using a sodium ionization model that includes photoionization by stellar UV flux and radiative recombination, we show that the ionization depth in the planet’s atmosphere, a function of angle from the planet’s substellar point, can reach a pressure greater than 1 mbar at the day/night terminator. Ionization leads to a significant weakening of the sodium feature. Silicate and iron clouds reside at a pressure of several mbar, and their opacity increases absorption in bands directly adjacent to the sodium line core. Including ionization and clouds, we obtain a feature just at the upper limit of the observational error bars. Based on studies of sodium in the Earth’s atmosphere, we argue that the amount of ionization could be greater than our model predicts.