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Photochemistry and transport-induced quenching on extrasolar giant planets: The importance of the C/O ratio

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Abstract

Recent analyses of transit and eclipse observations for some close-in extrasolar giant planets such as GJ 436b, HD 189733b, and WASP-12b suggest atmospheric CO/H_2O ratios that could be much greater than unity [1-4]. High CO/H_2O ratios are not expected from thermochemical equilibrium arguments or from disequilibrium processes such as photochemistry and transport-induced quenching if the atmospheres of these planets have a solar-like C/O ratio [5-7]. However, atmospheric C/O ratios that are close to unity can produce such behavior. We use a photochemical and thermochemical kinetics and transport model to examine the influence of the atmospheric C/O ratio on the chemistry and composition of the relatively cool "hot Neptune" GJ 436b, the warmer "hot Jupiter" HD 189733b, and the very hot WASP-12b. We find that the observable composition is extremely sensitive to the C/O ratio, which has some interesting consequences for atmospheric chemistry and transit/eclipse observations, particularly in relation to the relative abundances of HCN, C_2H_2, CH_4, and H_2O. The first two molecules (as well as NH_3 for more solar-like C/O ratios) are typically not included in spectral modeling and analyses of transit and eclipse observations, yet these species could be abundant enough to affect exoplanet spectra. We discuss the implications for atmospheric composition and suggest ways in which the planets could have developed an enhanced C/O ratio during their formation and evolution.

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