Compositional Trends in the Atmospheres of Hot Neptunes

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Neptune-sized extrasolar planets with close-in orbits (generally known as “hot Neptunes”) have become a common constituent of the growing population of exoplanets and planetary candidates. Based upon current views of exoplanet formation, many of these objects are expected to possess heavy element abundances (that is, elements heavier than hydrogen and helium) greatly in excess of solar ratios. Planets with high metallicities (10-10,000x solar) could display a wide range of atmospheric compositions, ranging from hydrogen-dominated atmospheres (similar to Uranus and Neptune), to Venus-like CO_2-dominated atmospheres, to more exotic metallic and oxygen-rich atmospheres, depending on the planet’s formation and evolutionary history.

In this study [1,2] we use thermochemical equilibrium and kinetics/transport disequilibrium models to investigate the influence of temperature, metallicity, and element abundance ratios (in particular the C/O ratio) on the chemistry and composition of hot Neptune atmospheres. From these parameters alone, a wide range of planetary compositions is chemically plausible for hot Neptunes, from low metallicity, H_2-rich, Neptune-like atmospheres to high metallicity, H_2-poor, H_2O, CO, CO_2, and O_2-dominated atmospheres.

We applied our model results to the case of GJ 436b, a $1.4M_{Nep}$, $1.1R_{Nep}$ planet orbiting its host star at 0.03 AU. We find that a very high atmospheric metallicity is expected to yield a CO-rich, CH_4-poor atmosphere, providing a physically and chemically plausible model consistent with *Spitzer* secondary eclipse data for GJ 436b [3-5]. The possible chemical consequences of high metallicity and/or nonsolar C/O abundance ratios should therefore be considered for GJ 436b and other hot Neptunes.

[1] Moses, J. I. *et al ApJ,* **763**, 25 [2] Moses, J. I. *et al ApJ*, **777**, 34. Stevenson, K. B. *et al* 2010, *Nature*, **464**, 1161 [3] Madhusudhan, N. and Seager, S. 2011, *ApJ*, **729**, 41 [4] Line, M. R. *et al* 2011 *ApJ* **738**, 32