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# A comparative analysis of atmospheric chemistry of extrasolar planets

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We present a comparative analysis of the atmospheric compositions of several transiting extrasolar planets, as inferred from observations with the Spitzer, HST and Kepler space telescopes. And, we discuss in detail the constraints on chemical abundances and temperature structure for two exoplanets with extreme atmospheric chemistry - the very hot Jupiter HAT-P-7b, and the hot-Neptune GJ436b. We used a newly developed exoplanet atmosphere retrieval method to determine statistical limits on the chemical compositions as required by the data. Our method facilitates calculating error contours in the space of chemical composition, the 1-D averaged temperature structure, and the day-night energy redistribution in the planet atmosphere, given photometric and/or spectroscopic observations. The statistical treatment involves large-scale computation of millions of 1D atmosphere models, spanning the large model parameter space. Our model includes a parametric pressure-temperature (P-T) profile coupled with line-by-line radiative transfer, hydrostatic equilibrium, and energy balance, along with prescriptions for non-equilibrium molecular compositions, and day-night energy redistribution. We report model fits to observations of several transiting exoplanets. For HAT-P-7b, we report model fits to observations of the planet dayside obtained with the Spitzer, Kepler and the EPOXI spacecraft. Our results indicate that while the observations of HAT-P-7b are best fit with models with a thermal inversion, the abundances of TiO and VO required to fit the data are sub-solar by a few orders of magnitude. The apparent under-abundance of TiO/VO implies that an hitherto unknown absorber must be responsible for the thermal inversion. On the other hand, models without a thermal inversion can, in principle, fit the data reasonably well. However, the latter scenario requires this very hot Jupiter atmosphere to be dominant in methane, as opposed to carbon monoxide, thereby signaling extreme non-equilibrium chemistry again. For GJ 436b, we report the first detailed constraints on the atmosphere of a hot Neptune. And, we discuss in detail the limits on the various channels of equilibrium and non-equilibrium chemistry required to explain the observations.