Spectral decomposition: a method to classify exoplanets spectra

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We introduce a simple but powerful technique to estimate the contribution of each atmospheric constituent in its spectrum, averaged over all pressures. Estimating these contribution coefficients provides us with a tool to quantitatively study relative importance of individual species in both emission and transmission spectra.

We employ this spectral contrast between molecular features, namely water and methane, to explore the parameter spaces where either methane or water is the dominant spectral feature. We propose a classification scheme, with four classes, for irradiated planets based on the dominancy of water and methane features in their atmospheric spectra and the association of their boundary with planetary effective temperature, surface gravity, metallicity and their host star's spectral type.

We find C/O$<$1 is not a global indicator for a water-dominated atmosphere and neither C/O$>\sim$1 is a ubiquitous indication of methane-dominancy. Consequently, the best temperature range to look for CH4 features is somewhat not very cold as one might expect, ranging from 800k to 1500k and requiring carbon to oxygen ratio to be about 0.7 or higher. This temperature range is also in favor of less cloudy atmosphere in contrast to colder planets, however the presence of clouds is not unlikely and consequently the TP structure as well as species abundances might alter, and similarly non-equilibrium chemistry could also change the spectral appearance of these planets. We present the effect of non-equilibrium chemistry on these regions and show how non-equilibrium chemistry modifies the classification and the regions where it can be neglected.

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