Effect of metallicity and eddy diffusion on transmission spectra of hazy exoplanet atmospheres

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Recently, properties of exoplanet atmospheres have been constrained via multi-wavelength transit observation, which measures an apparent decrease in stellar brightness during planetary transit in front of its host star (called transit depth). Sets of transit depths so far measured at different wavelengths (called transmission spectra) for some exoplanets are featureless or flat, inferring the existence of haze particles in the atmospheres. Previous studies that addressed theoretical modeling of transmission spectra of hydrogen-dominated atmospheres with haze used some assumed distribution and size of haze particles. In Kawashima & Ikoma (2018), we developed new photochemical and microphysical models of the creation, growth, and settling of haze particles for deriving their size and number-density distributions in close-in warm (< 1000 K) exoplanet atmospheres.

In this study, we explore the dependence of the production rate of haze and the resultant transmission spectra on metallicity and eddy diffusion coefficient. We find that the photodissociation rates of the hydrocarbons, which are related to the haze monomer production rate, are basically smaller for higher metallicity in spite of their increased abundances. This is because of the enhanced photon-shielding effect by the major photon absorbers, H_2O, CO, CO_2, and O_2, existing at higher altitudes than the hydrocarbons. Thus, the transmission spectrum for higher metallicity atmosphere is less affected by haze. We also find that the efficient eddy diffusion yields a steep Rayleigh-scattering slope in the optical and more prominent molecular-absorption features, which is the dependence opposite of condensation clouds.

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