

Mineral clouds of fluffy aggregates: how they form in exoplanetary atmospheres and influence transmission spectra

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Observations of transmission spectra have suggested ubiquity of high-altitude clouds in exoplanetary atmospheres. Recent theoretical studies have examined the formation of high-altitude clouds; however, they usually need to assume vigorous vertical mixing to explain the observations, which is orders of magnitude stronger than that suggested from general circulation models. The discrepancy might be caused by an assumption of the compact spheres for cloud particles adopted in previous studies. Because the hot environment of exoplanets leads to the formation of mineral condensates, they potentially grow into fluffy aggregates with very low sedimentation velocity that can be easily transported to high altitude. In this study, we investigate the influences of the particle porosity on vertical profiles of the clouds using a microphysical model taking into account the vertical transport, particle growth, and porosity evolution of cloud particles. We will demonstrate that the particle density can be lower than the material density by 2–3 orders of magnitude. As a result, the vertical extent of the clouds is potentially much larger than that expected in previous studies. We also calculate synthetic transmission spectra with fluffy-aggregate clouds. The fluffy-aggregate clouds largely obscure molecular signatures in the spectra and produce a characteristic spectral slope in visible to near-infrared wavelength. Finally, we compare the synthetic spectra with the transmission spectrum of GJ1214b, a super-Earth suggested to have clouds at ~ 0.01 mbar in pressure, and find that the observed spectra can be explained by the mineral cloud of fluffy aggregates if atmospheric metallicity is higher than 100 times solar abundance. The predicted high atmospheric metallicity might encapsulate information about the formation process of GJ1214b.

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