スーパーアースGJ1214bにおける鉱物雲のモデル化:大気金属量への示唆
Modeling Dust Cloud Structure in Super-Earth GJ1214b: Implications for the Atmospheric Metallicity

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Recent transit observations have revealed that many exoplanets have featureless spectra. Such spectra indicate extremely metal-enhanced atmospheres or the presence of opaque clouds at high altitude. Although thick high-altitude clouds prevent us from directly probing the atmosphere beneath them, their existence might provide us some information about the dynamics and/or composition of the lower atmosphere. However, it is still unclear how atmospheric dynamics and composition would affect cloud structure in exoplanets because most previous studies neglected or at least parameterized the growth microphysics of condensate particles.

In this study, we aim to understand the relationship between the atmospheric metallicity and the vertical extent of dust clouds. Recently, we have developed a new cloud model that takes into account the vertical transport of condensate particles and particle growth via both condensation and coalescence (Ohno & Okuzumi 2017). With our cloud model, we examine the vertical distributions of dust clouds in GJ1214b as a function of atmospheric metallicity.

We find that the cloud top reaches beyond 10^{-3} bar for atmospheric metallicities of 10× solar abundance, but does not reach the height of 10^{-5} bar for all choices of the model parameters. From timescale arguments, we find that the dust cloud structure can be classified into three regimes: *Condensation–Diffusion* regime, *Coagulation– Diffusion* regime, and *Coalescence–Sedimentation* regime. The maximum height of the cloud top occurs at the transition of the *Coagulation–Diffusion* and *Coalescence–Diffusion* regimes. Comparison between the maximum height of the cloud top predicted from our model and the height indicated from the observations of GJ1214b rules out atmospheric metallicities of 1–100× solar abundance for this particular exoplanets. Consequently, our results suggest that the atmosphere of GJ1214b is depleted in hydrogen as suggested by previous independent modeling, or the cloud in GJ1214b is composed of haze particles produced by photochemical reactions at high altitude.

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