# 大気降着を考慮したN体計算によるスーパーアースの形成
# Formation of super-Earths and their atmospheres with *N*-body simulations

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A large number of super-Earths have been discovered by various exoplanet search programs that include the Kepler mission, which provide the perfect opportunity for a development of planet formation theory. In fact, recent *N*-body simulations have made major progress in understanding the origin of close-in super-Earths (e.g., Izidoro et al. 2017; Ogihara et al. 2018). In these previous studies, they focus on orbital properties (e.g., period-ratio distribution) and aim to reproduce them.

In this study, we also pay attention to the amount of atmospheres and make further progress in formation models of super-Earths. According to the mass-radius relation of transiting super-Earths, it is unlikely that they generally possess massive atmospheres. This is consistent with the fact that the occurrence rate of hot Jupiters is considerably smaller than that of close-in super-Earths. The amount of atmospheres would provide useful constraints on the development of formation models of super-Earths. The gas accretion onto super-Earth cores depends on several factors (e.g., formation history, disk evolution); therefore it is crucial to follow the planetary growth, the orbital evolution, and the atmospheric accretion self-consistently.

We perform *N*-body simulations of super-Earth formation in an evolving disk considering the accretion of atmospheres. In our simulations, we also consider the pebble accretion, which is a physical process in which protoplanets grow rapidly through accumulation of small particles under gas drag. The pebble accretion would help to accelerate the core formation of gas giants in the outer region. Moreover, the pebble accretion may play an important role in the accretion of close-in super-Earths.

In this presentation, we are going to discuss several important questions about the origin of super-Earths. For example, we aim to reveal realistic formation processes by results of *N*-body simulations that include the atmospheric accretion, the pebble accretion, and the disk evolution. Then we discuss properties of formed super-Earths and compare with observed super-Earth systems. We also determine whether the pebble accretion can prevent the accumulation of massive atmospheres.

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