CO-AGGREGATION OF CHONDRULES AND NANOMETER-SIZED MATRIX GRAINS IN THE SOLAR NEBULA: A NEW SCENARIO FOR ROCKY PLANETESIMAL FORMATION. S. Arakawa[1] and T. Nakamoto[1], [1]Department of Earth and Planetary Sciences, Tokyo Institute of Technology, Meguro, Tokyo 152-8551, Japan; arakawa.s.ac@m.titech.ac.jp

Introduction: Chondrules are millimeter-sized rock particles and they are the principal components of the most common meteorites, chondrites. This fact means that the majority of rocky planetesimals might be formed via accretion of chondrules. However, it is not yet understood how millimeter-sized chondrules grow into kilometer-sized planetesimals. This is because there are several difficulties for rocky planetesimal formation, e.g., the bouncing barrier, the fragmentation barrier, and the radial drift barrier.

Okuzumi et al. [1] revealed that icy planetesimals could be formed by direct aggregation of submicron-sized ice particles. This is because icy aggregates consisting of submicron-sized monomers are strong enough to avoid catastrophic disruption, and the internal densities of these aggregates formed from cluster-cluster aggregation process are low enough to avoid serious radial drift to the Sun. In addition, these aggregates can stay porous even if we consider the effect of the static compression by the ram pressure of the nebular gas or the self-gravity [2].

If the building blocks are only millimeter-sized chondrules, then bouncing and fragmentation of chondrules might be severe problems. However, chondrites consist of not only chondrules but also matrix grains. In addition, matrix grains are not millimeter-sized but micron-sized [3] or even nanometer-sized [4]. Arakawa and Nakamoto [5] argued that the size distributions of matrix grains indicate that these fine grains are formed by evaporation and recondensation events in the solar nebula [6], and they initially condensed as nanometer-sized grains. The existence of fine matrix grains is important because the critical collision velocity for collisional growth depends on the size of monomer components [7], and the critical velocity exceeds the maximum collision velocity when matrix grains are smaller than ~ 10 nm.

Model: We propose a scenario in which rocky planetesimals are formed via co-aggregation of chondrules and nanometer-sized matrix grains. We verify whether the growth of aggregates is rapid enough to overcome the radial drift barrier by comparing the timescales of growth and radial drift.

We assume the minimum mass solar nebula [8]. The structure of dust aggregates is obtained from the formula given by Kataoka et al. [9]. The radius of nanometer-sized matrix grains is 2.5 nm and the radius of chondrules is 0.25 mm in this study.

Results: Our calculations reveal that aggregates of chondrules and matrix grains can overcome the radial drift barrier. Figure 1 shows the growth pathway of aggregates at 1 au from the Sun. We assume the alpha parameter associated with the strength of turbulence is 10^{-4} in this study. We also plot the temporal change of the growth timescale in Figure 2, and the result suggests that what we can observe in protoplanetary disks are not monomer matrix grains but centimeter-sized fluffy aggregates of chondrules and matrix grains.

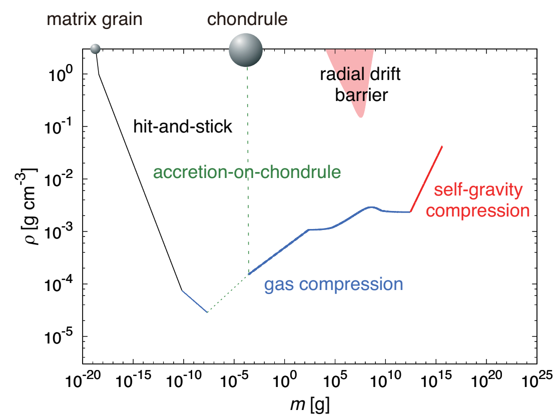

Figure 1: The pathway of planetesimal formation.

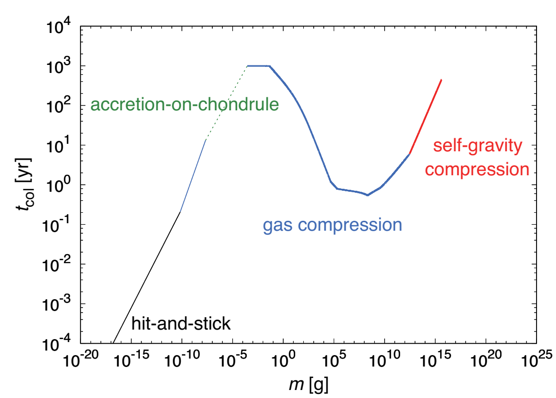

Figure 2: The temporal change of the growth timescale.

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