Forming Chondrite Parent Bodies via Direct Aggregation of Chondrules and Matrix Grains

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Chondrites consist of chondrules and matrix grains, however, how mm-sized chondrules and μm- and nm-sized matrix grains co-accrete in our solar nebula is not yet known. Our recent paper [1] proposed a new scenario that rocky planetesimals are formed via direct aggregation of nanometer-sized condensates produced by flash heating events [e.g., 2], which might also be associated with the chondrule formation [e.g., 3].

Here we develop this direct aggregation scenario. We analytically calculate how co-accretion of chondrules and matrix grains occurs in the protoplanetary disks and whether compound aggregates consist of chondrules and fluffy matrices can break through the radial drift barrier without catastrophic fragmentation. As a first step, we do not consider the mass distribution but consider two types of aggregates, that is, chondrule-and-matrix compound aggregates and chondrule-free matrix aggregates.

Our calculations reveal that nanometer-sized matrix grains help compound aggregates growing into rocky planetesimals. The timescale of growth is of the order of 10^3–10^4 years at the 1 au from the Sun. In addition, compound aggregates spent most of the times when the masses are 10^{-4}–1 g or the radii are 1–10 cm. Such fluffy aggregates might be stirred and these dust aggregates might be observed on the surface of protoplanetary disks [e.g., 4].

However, our calculations also find a new problem for "chondritic" planetesimal formation, that is, leapt out of chondrules from fluffy matrices. Although these chondrules which are once ejected from compound aggregates might be re-captured by fluffy aggregates which lost chondrules when they grow enough, a detailed study of this problem must be needed.

[1] Arakawa & Nakamoto (2016), *The Astrophysical Journal Letters* 832, L19. [2] Miura *et al*. (2010), *The Astrophysical Journal* 719, 642-654. [3] Soulie, Libourel & Tissandier (2017), *Meteoritics & Planetary Science* 52, 225-250. [4] Stolker *et al*. (2016), *Astronomy & Astrophysics* 595, A113.