Formation of SiC grains in the ejecta of core-collapse supernovae

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SiC grain is one of the most well-studied grain species among presolar grains discovered in primitive meteorites. According to their unusual isotopic signatures, a tiny fraction of SiC grains, called type X, are believed to be produced in the ejecta of core-collapse supernovae. However, there has been no theoretical study that predicted the formation of SiC grains in supernovae. This is mainly because, in the C-rich environment, C grains, whose condensation temperature is higher than that of SiC grains, first condense to consume up C atoms available for the formation of SiC grains (Nozawa et al. 2003).

In this study, we explore the formation of SiC grains in supernovae, considering the novel formation path via SiC molecules. In terms of grain formation, we consider, as growth processes of SiC grains (clusters), the attachment of SiC molecules onto SiC grains (accretion growth) and the coagulation through grain-grain collisions (coalescence growth). This is the first study that treats the formation of molecules, nucleation of stable clusters, accretion growth, and coalescence growth of grains in a consistent way.

We first show that a significant amount of SiC molecules can form in a C-rich environment. Then, we find that the formation of SiC grains is possible even after C grains form: by considering the formation path involving SiC molecules, SiC grains can condense without being affected by the formation of C grains. We emphasize that this study realized, for the first time, the formation of SiC grains in the supernova ejecta theoretically. However, the size of SiC grains calculated for the typical physical condition of supernovae is smaller than those measured for type X SiC grains (< 0.1 micron). This implies that large SiC grains with 0.1-20 micron as observed would be formed in highly dense gas clumps in the ejecta.