P137-004 Room: 301B Time: May 30 9:36-9:48

Fragment-collision model for compound chondrule formation: Size dependence of collision probability

Hitoshi Miura[1]; Seiji Yasuda[2]; Taishi Nakamoto[3]

[1] Department of Earth Sciences, Tohoku University; [2] Pure and Applied Sciences, Tsukuba Univ; [3] Tokyo Tech

Chondrules are millimeter-sized, once-molten, spherical-shaped grains mainly composed of silicate material. They are abundant in chondritic meteorites, which are the majority of meteorites falling onto the Earth. They are considered to have formed from chondrule precursor dust particles about .56 billion year ago in the solar nebula; they were heatd and melted through flash heating events in the solar nebula and cooled again to solidified in a short period of time. Typical chondrules are single spherical objects, while compound chondrules are composed of two or more chondrules fused together. They are rare in all chondrules (~4% [e.g., 1]), but occur in many classes of chondrites, so they offer crucial information regarding the physical and chemical state of solid materials during chondrule formation. Recently, we propose a new scenario for compound chondrule formation in the framework of the shock-wave heating scenario, fragment-collision model, which can account for the observed fraction of compound chondrules [2]. In this model, a cm-sized silicate dust particle (parent) are heated and melted by the gas frictional heating, then the molten parent is disrupted due to the strong gas ram pressure. Many small fragments (ejectors) are extracted from the molten parent particles and accelerated by the ambient gas flow. The mutual collisions between ejectors will occur and cause the compound chondrule formation.

In this model, it is suggested that the mutual collisions are more likely to occur on a pair of different-sized ejectors than a similar-sized pair because the acceleration of ejectors depends on their sizes. The difference of the acceleration results in the large relative velocity between ejectors, so the collisions are encouraged. In observations, a compound chondrule with the different-sized pair is frequently observed more than the similar-sized pair. The mean value of the size ratios of secondaries to primaries is about 0.3 [1]. If the fragment-collision model accounts for the observed size ratio of compound chondrules, it is a strong evidence that these compound chondrules have been formed by the fragment-collision. However, in our previous work, only the collision probability between two same-sized ejectors was derived. The purpose of this study is to obtain the collision probability between two different-sized ejectors based on the formulation of the fragment-collision model [2].

We take into account the mutual collisions satisfying the following two conditions: (1) colliding two ejectors cool and viscous enough not to fuse into one single droplet, and (2) collisional velocity does not exceed the critical value above which the destructive collision will occur. The collision probability, P_{coll}, is derived as a function of the size ratio of the smaller ejector to the larger one, r_2/r_1. When $r_1/r_2 = 1$ (same-sized pair), the acceleration is completely equal, so only the small velocity dispersion between ejectors can be used for the mutual collisions among them. It results into the small collision probability. As r_2/r_1 decreases, the collision probability increases by a few orders of magnitude because of the difference of the acceleration. However, P_{coll} has a peak at a certain value of r_2/r_1, then turns to the decrease as r_2/r_1 decreases. It is due to the destructive collision. We found that the value of r_2/r_1 at the peak P_{coll} depends on the critical destructive velocity above which the destructive collision will occur. Based on above results, we will discuss the condition for the compound chondrule formation and compare with the observations.

References: [1] Wasson et al. (1995) GCA 59, 1847. [2] Miura et al. (2008) Icarus, in press (arXiv:0711.0427).