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# Growth, destruction, and transport of protoplanetary dust: Implications for meteoritics and astronomical observations

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Global redistribution of dust in protoplanetary disks plays a crucial role in various aspects of the early (extra-)solar system evolution. This process controls the spatial dust distribution in the disks, which is a major factor in determining the dynamical properties of the resulting planetary systems. The observational appearance of the disks is also affected by the spatial dust distribution. In addition, it leads to the spatial and temporal variations in the local dust-to-gas ratio because of the difference in the radial mobility of dust and gas. This could be responsible for the chemical and isotopic diversities observed in chondritic components such as chondrules and CAIs.

The redistribution process is controlled by collisional growth of dust particles because the velocity of inward drift of dust particles caused by gas drag strongly depends on their sizes. However, there is still no general consensus on how large dust paticles can really grow by sticking due to intermolecular forces. The collision velocity of dust particles induced by turbulence increases with dust growth and finally becomes as large as several tens of m $s^{-1}$for m-sized particles. Numerical simulation of collisional growth suggests that fluffy dust particles dissipate the kinetic energy so efficiently that they can stick at the collision velocity of 50 m $s^{-1}$[1]. If this is the case, dust grains may continue to grow in high speed collisions and finally become km-sized planetesimals. In contrast, laboratory experiments indicate that destruction (or bouncing) inhibits dust growth above the threshold collision velocity of a few m $s^{-1}$[2]. In this case, growth of dust particles due to intermolecular forces ceases at the sizes much smaller than planetesimals. These two scenarios result in very different predictions for the dust redistribution process.

In this study, we simulate growth and radial drift of dust particles in a protoplanetary disk in the case where dust growth ceases due to destruction above the threshold collision velocity of several m $s^{-1}$. The main results of our simulation are summarized as follows. In the inner region of the disk, dust particles stop growing at 0.1-1 mm in radius, which is comparable to the typical chondrule size. This implies that the size of chondrules are determined by the stickiness of their precursor dust particles. Icy dust particles migrated from the cold outer disk releases water vapor at the snow line, leading to an enhancement of water vapor in the inner disk. This effect potentially explains the distinct differences in the oxygen isotopic composition of CAIs and chondrules if $H_2O$ ice in the solar nebula was $^{16}O$-poor relative to the solar composition [3]. The duration of the enhancement strongly depends on the threshold collision velocity of icy dust particles. It decreases with increasing the threshold velocity because icy particles become larger and drift more rapid. If the threshold velocity is as large as 10 m $s^{-1}$, the enhancement lasts for only a few $10^5$ yr. In contrast, if the threshold velocity is a few m $s^{-1}$, the enhancement continues over $10^6$ yr, which is comparable to the duration of chondrule formation. The simulation with and without dust destruction result in very different radial profiles of the dust surface density in the outer disk. This suggests that high-resolution observation of dust emission may provide another way to judge whether or not dust destruction occurs in the real disks.

References: [1] Wada et al. 2009. ApJ 702:1490-1501. [2] Blum J. and Wurm G. 2008. Annual Review of Astronomy & Astrophysics 46:221-5. [3] Yurimoto H. and Kuramoto K. 2004.Science 3 05:1763-1766.

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