Importance of Collisional Sticking of Fine Particles in Debris Disks

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High-velocity (several hundreds m/s) collisions in planetary siystems are believed to lead to collisional fragmentation. Once collisional fragmentation of kilometer-sized or larger planetesimals occurs, the collisional cascade grinds down to micron-sized or smaller dust grains, which are shortly removed by the radiation pressure or other effects. Therefore, the size distribution of dust grains are naturally determined by the quasi steady state evolution in collision cascades, which show simple power law distributions. Debris disks are formed from collisional cascades. Their spectral energy distributions (SEDs) are mostly determined by the size distribution because debris disks are optically thin. However, some SEDs of debris disks require the size distributions much steeper than those given by collisional cascades. To reconcile it, the artificial reduction factor for the sub-millimeter fluxes was used for debris-disk SED fittings (e.g., Wyatt 2008).

Recent laboratory experiences show such collisions of micron-sized or smaller fine particles result in sticking. Taking into account collisional sticking, we carried out simulations of collisional evolution in debris disks. We find collisional evolution with sticking results in a steeper size distribution.

We perform collisional evolution simulations considering the debris disk around HD114082. The disk is shaped as a ring and its radius and width are obtained through high resolution observations (Wahhaji et al 2016). Therefore, it is a good target to test the collisional model with sticking. We calculate the SEDs according to the resultant size distributions. A simple power law distribution with index -3.5 explains the fluxes in $\sim$ 10–100μm, while it overestimates the flux at longer wavelengths. The result of collisional evolution without sticking is better than the overestimate in the simple power law case, but the flux at $\gg 100\,\mu$m is overestimated. The result with sticking is most likely to explain the SED.

Therefore, collisional cascades with sticking result in steeper size distributions for millimeter-sized or smaller dust grains. This modification may naturally explain the reduction of (sub)-millimeter fluxes in debris disks.