Silicate features in Debris Disks

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Debris disks are faint dust disks around main sequence stars. Some warm debris disks exhibit silicate features in their spectral energy distributions (SEDs), which may contain important clues about the process of planet formation. Radiation pressure from host stars blow out small dust grains $\lesssim 10\,\mu$m, while silicate features are not explained by the thermal emission from large grains. Consequently, these features are often attributed to the recent production of small grains through stochastic collisions, such as giant impacts, potentially linked to planet formation. However, previous discussions have lacked quantitative estimates of small dust production rates. If production is sufficiently high, the abundance of small grains may exceed the level inferred from silicate feature observations.

In this study, we perform simulations for collisional evolution of bodies in warm debris disks, explicitly account both the production of small grain and their removal by blow-out. We obtain the time evolution of the size distribution of bodies, which reaches a quasi-steady state on short timescales. Our results show that in young, massive disks, the production rate of small dust is sufficient to maintain a population capable of producing observable silicate features. As collisional evolution reduces the total disk mass over time, the production rate of small dust also decreases, eventually suppressing silicate features. Thus, we conclude that silicate features are more likely to be observed in young, massive, warm debris disks.