Rolling friction between dust monomers explored by molecular dynamics simulations

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Dust is considered to be aggregates composed of submicrometer-sized particles (dust monomers) and it grows by collisional sticking, which has been investigated by using simulations based on the discrete element method (e.g., Wada et al. 2007, 2008, 2009, 2013; Suyama et al. 2008, 2012; Arakawa et al. 2022). Arakawa et al. (2022) investigated the collisions between porous dust aggregates and found that the rolling friction contributed to the energy dissipation during collisions under certain collisional conditions. The rolling friction is modeled by Domink & Tielens (1995), in which the rolling friction is proportional to the critical displacement. However, the value of the critical displacement has not been constrained well. In this study, we aim to clarify the rolling friction by using molecular dynamics simulations.

We performed molecular dynamics simulations, which integrate each atomic motion and analyze the underlying physical processes. We prepared the contacting dust monomers and simulated their rolling motions. The angular velocity of dust monomers decreases with time, and we analyzed the torque acting on them from the temporal evolution of angular velocity. We found that the critical displacement is approximately 0.2 - 0.3 nm. We also found that the torque sometimes changes with rolling due to peeling at the contact surface. This peeling enhances the torque, resulting in a large effective critical displacement. At higher temperatures, the peeling occurs more frequently. Therefore, the rolling friction increases with increasing temperature. Such a peeling phenomenon can be observed in the atomic alignments.

In our presentation, we show these results and discuss their implications for the dust growth.