Collisional disruption of planetesimals: dependence of material strength

*Ryo Suetsugu[1], Hidekazu Tanaka[2], Hiroshi Kobayashi[3], Hidenori Genda[4]

1. University of Occupational and Environmental Health, 2. Tohoku University, 3. Nagoya University, 4. Tokyo Institute of Technology

Collisions are one of the most important processes in planet formation because planetary bodies in the Solar System are thought to have experienced a lot of collisions during the accretion process. Thus, collisional processes have been examined extensively. Roughly speaking, collisional outcomes can be classified into disruptive collisions and erosive collisions by the specific impact energy Q_R. In particular, the specific impact energy required to disperse the largest body such that it has exactly half its total mass after the collision is called the critical specific impact energy Q_{RD}^*. In the case of $Q_R>Q_{RD}^*$, collisions between planetesimals are regarded as disruptive collisions, while they are non-disruptive collisions for $Q_R << Q_{RD}^*$, whose mass ejection is small. The values of Q_{RD}^* have been investigated by laboratory experiments and numerical simulations. When the target is small enough to neglect the effect of the target's gravity, the critical specific impact energy is mainly estimated by laboratory experiments. As target size increases, collision outcomes gradually become dominated by the gravity of the target. However, direct experimental measurements of a large scale collision are difficult to carry out in the laboratory. Thus, the values of Q_{RD}^* for large targets are estimated via shock-physics code calculations, which compute the propagation of the shock wave caused by a high velocity collision: Lagrangian hydrocode such as Smoothed Particle Hydrodynamics (SPH) methods, or a hybrid code of Eulerian hydrocode and N-body. These numerical simulations showed the dependence of the value of Q_{RD}^* on various impact conditions such as target size, impact velocity, material properties, impact angle, and numerical resolution. Recently, we performed impact simulation using the grid-based code (iSALE) in the gravity regime, because almost all high velocity collisions have been examined by the SPH method. We showed that collision outcomes of the iSALE simulation agree well with those of the SPH simulation.
As mentioned above, material properties of the target affect collisional outcomes. However, the dependence of Q_{RD}^* on material properties was not studied in detail. In this study, we perform impact simulations in the gravity regime by using shock-physics code, iSALE. We will discuss the dependence of Q_{RD}^* on material properties and impact conditions for a wide range of specific impact energy, and compare our results with previous studies.

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