Collisional Disruption of Planetesimals in the Gravity Regime with iSALE Code

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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 in accretion process. Thus, collisional processes have been examined extensively. Collisional outcomes are characterized by the specific impact energy Q_R. Especially, Q_R required to disperse the largest body having exactly half the 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 erosive collisions when $Q_R^*<<Q_{RD}^*$.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 estimated mainly by laboratory experiments. With increasing the size of the target, collision outcomes gradually become dominated by the gravity of the target. However, direct experimental measurements of the large scale collision are difficult to be carried out in the laboratory. Thus, the values of Q_{RD}^* for the case of large target are estimated via impact simulations, which can solve shock wave caused by high velocity collision; Lagrangian hydrocode such as Smoothed Particle Hydrodynamics (SPH) methods or hybrid code of the 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, and impact angle. However, almost all high velocity collision has been examined by the SPH method. Recent impact simulations showed that collision outcomes obtained by the SPH methods depend on the number of SPH particles (Genda et al. 2015, 2017). Thus, the results of previous studies may have been influenced due to numerical resolution. Some previous studies used the grid-based hydrocode. However, the grid-based code is only used for the shock deformation immediately after collision, and the large part of the disruption is calculated by N-body simulation. Thus, collisional disruption by the grid-based code has not been sufficiently preformed. In this study, we perform impact simulations in the gravity regime by using shock-physics code, iSALE. We examine the dependence of Q_{RD}^* on numerical resolution and impact conditions for a wide range of specific impact energy from disruptive collisions to erosive collisions, and compare our results with previous studies. Furthermore, using numerical results obtained by the iSALE code and the crater scaling law, we will discuss the derivation of the semi-analytic formula for Q_{RD}^*.

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