P155-026 **Room: 301A** **Time: May 14 14:11-14:24**

Shock-wave heating model for chondrule formation: shape analysis of rotating droplet exposed to gas flow

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Chondrules are millimeter-sized, once-molten, spherical shaped grains universally contained in chondritic meteorites, which are the majority of meteorites falling onto the Earth. They are considered to have formed from chondrule precursor dust particles in the solar nebula; they were heated and melted through flash heating events in the solar nebula and cooled again to solidify in a short period of time. The shock-wave heating model is one of the most plausible models for chondrule formation. In this model, the chondrule precursor dust particles are heated due to the gas friction in the high-velocity rarefied gas flow.

Tsuchiyama et al. (2003) studied the chondrule shapes using X-ray microtomography. The external shapes were approximated as three-axial ellipsoids with a-, b-, and c-axes (axial radii are A, B, and C (A is equal or greater than B, and B is equal or greater than C), respectively). The plot of C/B vs. B/A (see figure) shows that (1) the shapes are diverse from oblate (A is almost equal to B, and B is greater than C), general three-axial ellipsoid (A is greater than B, and B is greater than C) to prolate chondrules (A is greater than B, and B is almost equal to C), and (2) two groups can be recognized (group-A and -B).

It is thought that the deformed shapes of chondrules reflect the deformations when the precursor dust particles melt in the gas flow. Tsuchiyama et al. (2003) suggested that the rotation of molten droplets plays an important role to deform the droplet shapes. The rotation naturally produces the oblate shapes, however, the prolate shapes cannot be explained. On the contrary, Sekiya et al. (2003) analytically derived the deformation and the internal flow of the droplets exposed to the gas flow, assuming that the non-linear terms of the hydrodynamical equations as well as the surface deformation are sufficiently small so that linearized equations are appropriate. However, their models could explain only the oblate shapes. As has been noticed here, although the ram pressure of the gas flow and the rotation of molten droplets play important roles to deform the droplet shapes, there is no report to consider those two effects simultaneously.

In this study, we simulate the rapidly rotating molten droplets exposed to the high-velocity gas flow by numerically solving three-dimensional hydrodynamical equations. We find that the molten droplet shape changes in response to the value of the angular velocity that the precursor dust particles obtain in the gas flow. We also analytically derive the three-dimensional shapes of droplets and find that the numerical simulations well match with the analytic solutions. From above analysis, we conclude that the rotation rate is an important factor to determine the droplet shapes. Moreover, we find that the droplet shapes as shown in our analysis seem to be similar to the chondrule data.

Figure: Attached figure shows the comparison between the chondrule shapes measured by Tsuchiyama et al. (2003) and the droplet shapes analytically derived in our study. The horizontal and vertical axes are the axial ratios B/A and C/B, respectively. The open circles indicate the chondrule data for various textural types (red=porphyritic, green=barred olivine, and blue=crypto crystalline) (Tsuchiyama et al. 2003). The curves are the analytic solutions derived in our study: shape sequences for various radii (200, 500, and 1000 micron) when the rotation rate changes gradually are shown. If there is no rotation, the droplet shape becomes oblate (B/A=1 and C/B is less than 1). As the rotation rate increases, B/A decreases and C/B increases. As a result, the droplet shape changes toward a prolate shape (B/A is less than 1 and C/B=1).

References: [1] Tsuchiyama A., et al., 2003, Lunar & Planetary Science Conference, abstract#1271, [2] Sekiya, M., et al., 2003, Progress of Theoretical Physics, 109, 717.