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Ejecta size distribution from hypervelocity impact cratering of planetary materials: Implication for dust production process of impact origin

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Abstract

We conducted hypervelocity impact experiments in order to understand dust production process by impact between planetary bodies. Sub-mm size aluminum spheres were accelerated to a velocity over 10 km/s by laser ablation and were shot into rocky targets. We analyzed the surface of the aerogel blocks deployed near the targets by an Electron Probe Micro Analyzer (EPMA) and counted the number of particles which contain the target material. We derived the size distribution of the ejecta ranged from a few μm to tens of μm in diameter. The slopes of ejecta size distribution vary with experimental conditions such as projectile diameter and impact velocity.

1. Introduction

The lifetimes of the interplanetary dust particles, 1-100 μm in size, are very short as compared with the solar system and other planetary systems because of the Poynting-Robertson drag. Thus continuous sources of new dust particles are required in order to maintain the dust population. Fragments generated by high velocity collisions among solid planetary bodies, such as asteroids, are believed to be one of the major sources of the interplanetary dust particles. Recent astronomical observations have shown that many stars have extensive circumstellar discs of dust particles. It was suggested that the infrared emission around the A5V star HD172555 is due to fine dust particles created by a hypervelocity (> 10 km/s) impact between rocky bodies [1]. In order to study the formation and evolution process of interplanetary dust particles and debris discs, it is of importance to understand the impact fragmentation and ejection process over a wide range of impact velocity. However, acceleration of macroscopic projectiles to velocities higher than 10 km/s has been a major technological challenge. Consequently, the dust production process at such impact velocity has remained highly unknown so far. In this study, we conduct impact experiments to study fragmentation and ejection process at collision velocities higher than 10 km/s using a GEKKO XII-HIPER laser at Institute of Laser Engineering of Osaka University in Japan [2].

2. Experiments

Aluminum projectiles of about 80-250 μm in diameter were accelerated to or higher than 12 km/s by laser ablation and were shot into rocky blocks, about 15 mm on a side. Aerogel blocks, 5 mm in thickness were deployed aside the target in order to capture the ejecta from the target. They were covered with a stainless-steel plate, 0.5 mm in thickness with 3 mm diameter holes. In order to minimize the effect of the plasma on the aerogel blocks and aluminum foils, we placed a copper plate of 1 mm in thickness as a shield between the projectile and the aerogel blocks. Figure 1 shows the experimental configuration.

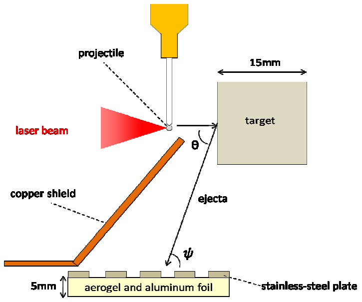

Figure 1: The experimental configuration, where θ and ψ denote the ejection angle and the incident angle to the aerogel block or aluminum foil, respectively.

3. Results

With EPMA mapping method [2], we analyzed the surface of the aerogel block (3.2 µm × 3.2 µm / pixel, 1024 × 1024 pixels) and counted the number of particles which contain the target material. The equivalent area diameter was adopted as the particle diameter. Figure 2 shows the size distribution of ejecta from dunite targets in Shot#33370 and Shot#33372, which ranged from a few µm to tens of µm in diameter. In Shot#33370, impact velocity and projectile diameter were 16.5±0.4 km/s and 247.8 µm, respectively. In Shot#33372, 60.8±2.0 km/s and 80.4 µm, respectively. The raw number of the particles is converted to the number per solid angle, using the diameter of the region (3mm), the distance between the target and the regions on the aerogel (r) and the angle of the impact onto the aerogel (ψ).

4. Discussion

The size distributions of ejecta in Shot#33370 (Figure 2a) have no inflection point at any ejection angles (θ). On the other hand, the size distributions of Shot#33372 (Figure 2b) have significant inflection points at any ejection angles. Accordingly, the number of dust sized fragments (< 10 µm) in Shot#33370 was larger than the number of dusts in Shot#33372. We explain this result by an analytical dust production model in which the amount of dust particles is proportional to the initial peak pressure of the impact and the isobaric region.

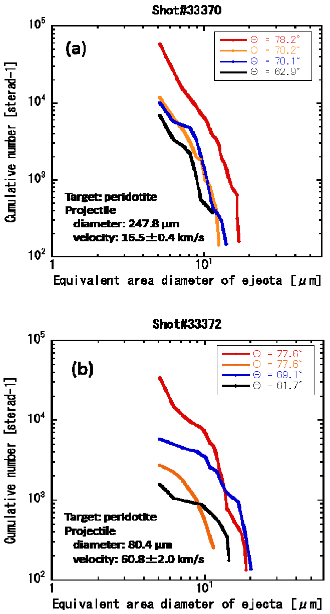

Figure 2: The cumulative size distributions of ejecta captured by aerogels in Shot#33370 (a) and in Shot#33372 (b).

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References

[1] Lisse, C. M. et al.: Abundant circumstellar silica dust and SiO gas created by a giant hypervelocity collision in the ~12 Myr HD172555 system, Astrophys. J., 701, 2019-2032, 2009.

[2] Kadono, T. et al.: Impact experiments with a new technique for acceleration of projectiles to velocities higher than Earth's escape velocity 11.2 km/s, J. Geophys. Res., 115, E0403, 2010.

[3] Takasawa, S. et al.: Ejecta size distribution from hypervelocity impact cratering of planetary materials, 41th Lunar and Planetary Science Conference, Texas. Abstract No. 1194, 2010.